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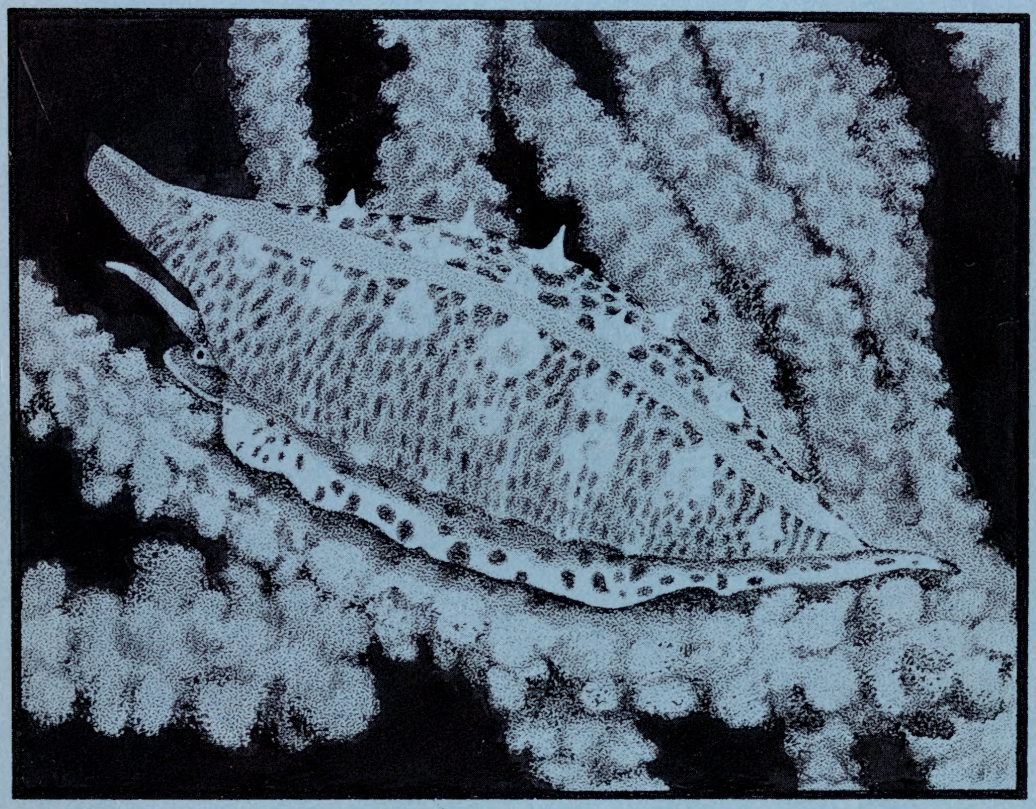
Marine Shells of Southern California



By JAMES H. MCLEAN
Curator of Invertebrate Zoology
Los Angeles County Museum of Natural History

SCIENCE SERIES 24, ZOOLOGY NO. 11

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LOS ANGELES COUNTY MUSEUM OF NATURAL HISTORY

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OCTOBER, 1969

PREFACE

This handbook is designed as a guide to the common shelled marine mollusks of the Pacific Coast from Santa Barbara to San Diego. Most species that occur at low tide and in subtidal areas under kelp beds are included. Intertidal collectors and skin and SCUBA diving collectors should therefore find the handbook especially useful. The 318 species treated constitute only about half of what could have been included had all of the rare and deep-water forms been covered.

Some new taxonomic and distributional information is presented, but without detailed treatment of controversial problems. Changes are indicated with minimal explanation. Innovations are distinguished from already published changes by others in two ways. First, where a new combination or a different specific name is used, the older usage is indicated thus: "previously listed as . . ." Second, the names listed in synonymy for the first time are distinguished from those discussed elsewhere by: "I regard . . . a synonym." Generally, synonyms are listed only to avoid possible confusion. Some new southern records for Californian province species are given, many of them based on Museum field work. Some broad range limits are narrowed down. For example, many early records of "Cape San Lucas" for Californian species are discounted because these species have not been found there again on recent expeditions. Locality information for the figured specimens is given in the appendix.

I am greatly indebted to Drs. Myra Keen and Eugene Coan of Stanford University for their careful reading and helpful criticism of the manuscript. The arrangement of the Tellinacea and Marginellidae was suggested by Dr. Coan, and his classification of these groups is adopted. For the arrangement of the chitons, and extensive help with the group, I am grateful to Mr. Spencer Thorpe, of El Cerrito, California. I also thank the photographic and art staff of the Museum for their help in preparing the illustrations.

J. M.
October, 1969

SHOWN ON COVER: *Simnia vidleri, x 5. Living animal with fully extended mantle. The animal is crawling on a branch of the gorgonian coral upon which it lives and feeds. Drawn by Mary Butler from a photograph by Jack McNeal.*

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The Californian Faunal Province

Southern California from Santa Barbara to San Diego is part of a region of fairly uniform faunal composition known as the Californian faunal province. Here temperature and other ecological conditions are similar, so that many of the same species occur throughout. The fauna can be characterized as subtropical, since surface temperatures range from summer highs of around 70° to winter lows of around 50° F. Thus, there is not a great deal of variation throughout the year, which is a contributing factor in the richness of the molluscan fauna. The northern limit of the Californian province is in the vicinity of Point Conception, just to the north of Santa Barbara. Cooler temperatures prevail in the temperate Oregonian province, which extends north of Point Conception into southern Alaska. The mollusks of central and northern California bear more resemblance to those of the Puget Sound area than to those of southern California.

The Californian province extends south along the outer coast of Baja California to the southern part of the peninsula, where the fauna is replaced by species of the tropical Panamic province. The larger portion of the subtropical Californian province is located south of the Mexican border. Here the molluscan fauna is less well known and the southern distributional limits of many species are yet to be defined.

Habitats

Rocky Intertidal: By far the most productive area in numbers of species for the intertidal collector is the rocky intertidal habitat. Places with rock cliffs above the tide line, rocky ledges and tide pools with loose rock, have the richest fauna. Littorinas and several limpets occur in the uppermost intertidal or splash zone. Exposed mussel beds have characteristic species. In the lower tide zone a wide assortment of species occur under rocks, in crevices, and tide pools. Many small and minute species may be found in gravel at the bottom of tide pools and associated with the eelgrass *Phyllospadix*. In areas where soft shale rock is exposed, several kinds of boring clams may be found. Rocky areas with diverse collecting conditions occur along the Palos Verdes Peninsula in Los Angeles County, at Corona del Mar in Orange County, part of which is now a State preserve, and at La Jolla and Point Loma in San Diego County.

Rubble Reefs: Along many beaches in southern California low tide exposes a rocky expanse consisting of large cobbles and small boulders. Fine sand rather than gravel accumulates between the rocks, producing a habitat subject to change due to shifting sand levels. Although collecting is not as rich in these places, some species are found there that can withstand the changing conditions. Several species of chitons are characteristic of this habitat.

Sandy Beaches: Least productive of the intertidal collecting areas are sandy beaches where only a few species live, such as the pismo clam and the bean clam. Occasionally, after storms, some offshore species may be cast up.

Bays and Lagoons: Intertidal collecting along the sandy or muddy shores of bays and lagoons in southern California is productive in numbers of species, few of which occur in exposed rocky areas along the open coast. At the drift line in the back bays are *Cerithidea* and two pulmonate snails. Other snails appear at low tide on the sand and mudflats. Numerous clams burrow beneath the surface. Rocky areas and pilings in the bays have a rich attached fauna of mussels and oysters, as well as several species of predatory snails. Breakwaters and rocky channels at the entrances to bays are good collecting areas at low tide and just below the tide line. Tidal currents in these channels provide an abundance of planktonic food for the sessile species, which in turn support a large population of the predatory species. Good collecting areas include Mugu Lagoon in Ventura County, Anaheim Bay in Los Angeles County, New-

port Bay in Orange County, and Mission Bay in San Diego County. Some collecting is possible in certain areas of the Los Angeles-Long Beach harbor and San Diego Bay, but pollution limits the fauna.

Rocky Subtidal: This habitat is an extension of the lowermost intertidal zone, an area effectively collected only by diving. Many species seldom exposed at low tide are fairly common in the sublittoral zone. Locations under kelp beds have proven to be the richest collecting grounds. About 150 species can be collected in a single day if gravel samples are taken for the small and minute forms. At depths below 70 feet, in water much cooler than at the surface, advanced divers may find still other species.

Sand and Mud Bottoms Offshore: In protected bays and sandy areas along the exposed coast at depths beyond the influence of the surf, a rich and entirely different molluscan fauna occurs. Although patient divers may find specimens on sand bottoms, the most profitable way of collecting is by dredging. Space limitations prevent treatment of this fauna here, but some of the species may be identified from handbooks listed in the bibliography.

Collecting Methods

A fishing license is needed to collect mollusks in California. Abalones and certain clams have size limits, bag limits, and season limits. For details, consult the Sport Fishing Regulations pamphlet obtainable with the fishing license.

Although most mollusks are easily collected by hand, special equipment is needed for some; shovels for clams, a flexible knife for limpets and chitons, and rock hammers for boring clams. Gloves should be worn for protection from cuts and scratches. In rocky intertidal areas many species occur only underneath or on the undersurfaces of rocks, which must be turned to find them.

Minute gastropods may be collected by scooping up a thin surface layer of gravel from the bottoms of tide pools for sorting through screens of decreasing size mesh. Another productive method is to tear eelgrass roots apart in a bucket of water. Shells will sink with the sand and gravel for later screening and sorting. SCUBA divers working under kelp should be able to collect at least 50 species of minute shells in a quart or so of gravel.

Shell collectors are urged to be conservation conscious and preserve the natural populations of marine life. With the ever increasing urbanization in southern California, the intertidal zone is invaded more frequently and the fauna in the most accessible collecting areas is becoming depleted at a rapid rate. Disturb the habitat as little as possible, and encourage others to do the same. Overturned rocks should always be restored to the original position. Failure to do so destroys the habitat: forms of plant and animal life attached to the upper sides will die if left on the bottom, as will life on the under sides if left exposed. Take only small representations of each species, leaving the juvenile and less perfect specimens to breed and replenish the population.

Preservation and Cleaning

Preservation and cleaning of shells may be done in several ways. Large gastropods and clams are effectively cleaned by boiling for several minutes, after which the soft parts can be removed with a small pick or knife. The operculum of each gastropod specimen should be retained and kept inside the aperture with a small piece of cotton. Small gastropods may be soaked in alcohol and dried without removing the animal. This method has the advantage of retaining the operculum in place. Grain alcohol, denatured alcohol, or rubbing alcohol may be used. Limy incrustations on shells can be removed by soaking the specimens in laundry bleach, followed by rinsing and careful work with a small pick. This treatment may remove the periostracum, which is not always desirable. A light application of mineral oil helps to restore the color and avoid a chalky appearance.

Labeling and Care of the Collection

The next step is labeling. Of more immediate importance than the name or identification is the locality information. In a well labeled collection each species lot bears a label giving precise information as to where collected, in-

cluding locality, county, and state, together with the collection date and name of collector. Accurate data of these kinds will permit use of the collection for scientific purposes. Identification can always be done later.

Specimens may be put in small cardboard trays, glass vials, or plastic boxes large enough for the specimens and label. The collection should be arranged systematically and kept in a cabinet with broad shallow drawers. An arrangement, as in this or another handbook, should be employed.

Format

In the species accounts that follow, information is given under family, generic, and species headings. General information on structure, distribution, and natural history applying to the entire group is given under the family heading. Generic headings consist of the genus name, the author who proposed it, and the date of publication. Information under this heading applies to all species treated in the genus. The scientific name of each species includes the generic and specific name, the name of the author who proposed the specific name, and the year of publication. Parentheses are placed around the author's name and date if the species was originally proposed in a genus other than the one now used. Information for each species includes a description, dimensions, general habitat, relative abundance, and geographic distribution.

Many species have acquired common names and these are given after the scientific names. Other small and less frequently encountered species do not have a common name and no attempt is made to assign names. Advanced collectors and students of mollusks use only the scientific names. Those making shell collections are urged to use scientific names.

Although the scientific names are universally understood, it is sometimes necessary to change old familiar names because of new understandings of relationships or to correct errors in nomenclature. Consequently, the names used in this book may differ from those in other books. An effort has been made to use those names least likely to change in the future.

The Classes of Mollusks

Seven classes are recognized in the phylum Mollusca. Each is based upon major distinctions in the shell and soft parts; the names are based on features pertaining to either the shell or foot. The first four classes have shelled representatives in shallow water in southern California and are treated in this handbook.

Gastropoda: Univalves, snails. "Stomach-footed"

Polyplacophora: Chitons. "Many plates"

Pelecypoda: Bivalves, clams. "Hatchet-footed"

Scaphopoda: Tooth shells, tusk shells. "Shovel-footed"

Cephalopoda: Octopus, squid, nautilus. "Head-footed"

Aplacophora: Solenogasters. Shell-less, worm-like animals often united with chitons as the class Amphineura. "No plates"

Monoplacophora: Neopilina. Shell limpet-like, with 5-6 pairs of gills and internal organs; three deep water species. "Single plate"

Class GASTROPODA

The gastropods or univalves comprise the largest class of mollusks and display a great diversity of form. Some have successfully invaded freshwater and others are found on land, a few at high elevations. They possess a distinct head with sensory tentacles and eyes. The foot of most is flat and is adapted for creeping or gliding.

Gastropods differ from other classes of mollusks chiefly in having undergone a phenomenon known as torsion, where the mantle cavity, gills, and other associated organs of the larval snail rotate to a forward position. Torsion takes place during the early development of the gastropod. Spirally coiled gastropods have generally lost the paired organs on the inner side of the coil.

Although most gastropods may be identified from their shells alone, the current classi-

fication scheme is based almost entirely upon soft parts. One of the most useful anatomical characters is the radula, a rasp-like organ bearing rows of teeth. A microscope must be used to study the shape and structure of the radular teeth. Most families have a characteristic radula and in some the radula can even be used for species determinations.

GLOSSARY OF GASTROPOD SHELL TERMS

Aperture: Opening of the last whorl, through which the head and foot of the living animal emerge.

Apex: Early whorls or tip of the spire; this is the posterior end.

Axial ribs: Sculpture parallel to the axis of coiling.

Base: Anterior end of the shell, the lower part to the left of the aperture if the shell is held apex up.

Canal: Extensions of aperture; anterior or siphonal canal protects the siphon; posterior canal may be called the anal notch.

Cancellate sculpture: Formed by axial ribs and spiral cords intersecting at right angles.

Carina: Prominent spiral keel or ridge.

Columella: Shell pillar surrounding the axis of coiling.

Columellar fold: Spiral ridge on the columella.

Denticle: Tooth-shaped projection at the inner or outer lip.

Growth lines: Simple axial sculpture resulting from successive growth increments on the outer lip.

Inner lip: Inner margin of the aperture.

Incised sculpture: Sharply cut grooves.

Operculum: A horny, sometimes calcified structure attached to the foot that may seal the aperture of the shell when the animal retracts.

Outer lip: Outermost margin of the aperture, the growing edge of the shell.

Parietal wall: Broad inner lip area of the body whorl.

Periostracum: Horny or fibrous outermost layer of the shell, composed of conchiolin.

Periphery: Outmost part of the whorl that projects farthest from the axis.

Plicae: Folds. Columellar plicae are folds on the columella. Plicate: folded or twisted.

Shoulder: Uppermost projecting area on the whorl.

Spire: Whorls at the smaller or apical end of the gastropod, posterior to the aperture.

Striae: Sculpture of minute grooves.

Suture: Line marking the junction of the whorls.

Umbilicus: Open cavity at the base, in the axis of coiling.

Varix: A larger than ordinary axial rib, representing the outer lip during a resting growth stage. Plural: varices.

Whorl: A turn or coil in a spirally coiled shell. The body whorl is the last and most inflated; the penultimate is the next to the last whorl.

Subclass PROSOBRANCHIA

Most shelled marine gastropods belong to this group where torsion, the frontal placement of the mantle cavity and internal organs, is apparent in the adult snail. The group derives its name from the forward position of the gills. Another name for the subclass, Streptoneura, refers to the twisted nerve cords resulting from torsion.

Order ARCHAEOGASTROPODA

The archaeogastropods or "old gastropods" include families having primitive characteristics, such as a pearly or nacreous shell and holes or slits in the shell serving as the exit for water currents. Gills in the most primitive families are paired. More advanced members of the order have spirally coiled shells with rounded apertures, single gills, and lack the shell slits. The radula in most of the archaeogastropods is rhipidoglossate, consisting of numerous teeth in each row. In the true limpets spiral coiling is lost in the adult and the radula has a reduced number of teeth, but the condition of the gill and other structures is primitive. The entire group is primarily herbivorous. Archaeogastropods graze on microscopic algae, detritus, or chunks of algae.

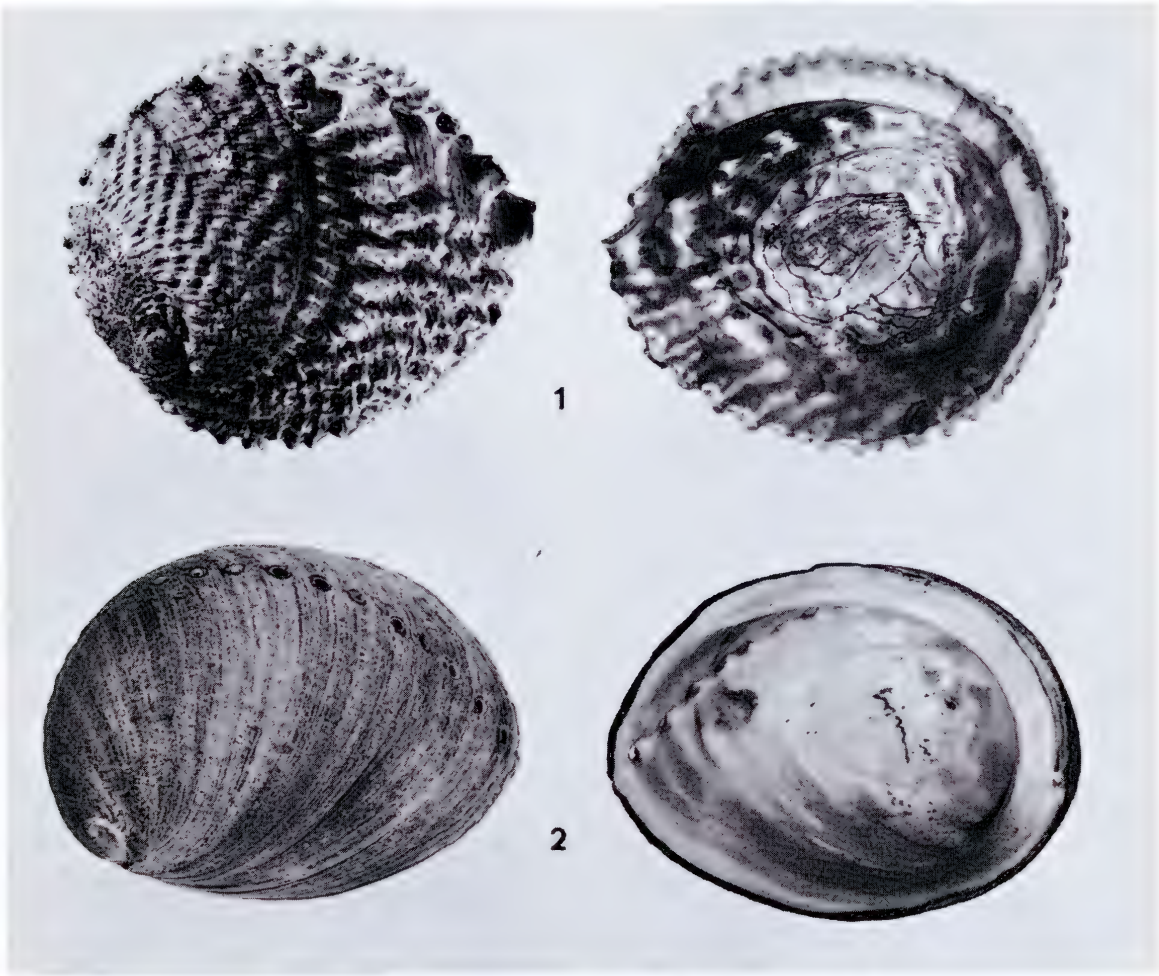

Figure 1. **1,** *Haliotis corrugata,* x .4; **2,** *H. cracherodii,* x .6.

Family HALIOTIDAE

The abalones have large, loosely coiled oval shells exhibiting a series of open holes, used as excurrent openings for water circulation. Each species has a highly characteristic epipodium, bearing tentacles and sensory processes, located on a ridge on the mantle between the shell and foot. The animal has two gills, the right one slightly reduced in size. The nacreous interior of the shell is a primitive character. As abalones are highly valued for food, a minimum legal size has been set for each species. An excellent treatment of the California species is given by Cox (1962) in a bulletin published by the California Department of Fish and Game. The red abalone, *Haliotis rufescens* Swainson, 1822, and the flat abalone, *H. walallensis* Stearns, 1899, more common in northern California, are omitted here.

Haliotis Linnaeus, 1758

1.1 *Haliotis corrugata* Wood, 1828. PINK ABALONE. Shell relatively elevated, 2-4 open holes on tubular projections. Sculpture of spiral ridges crossed by diagonal ridges most prominent below the row of apertures, giving a corrugated effect. Color dull green to reddish brown, muscle scar prominent, interior strongly iridescent in shades of pink and green. Legal size limit six inches in minimum length. The pink abalone is strictly sublittoral, living at depths of 20-80 feet, chiefly in areas having giant kelp. Range: Point Conception, California, to Asuncion Island, central Baja California.

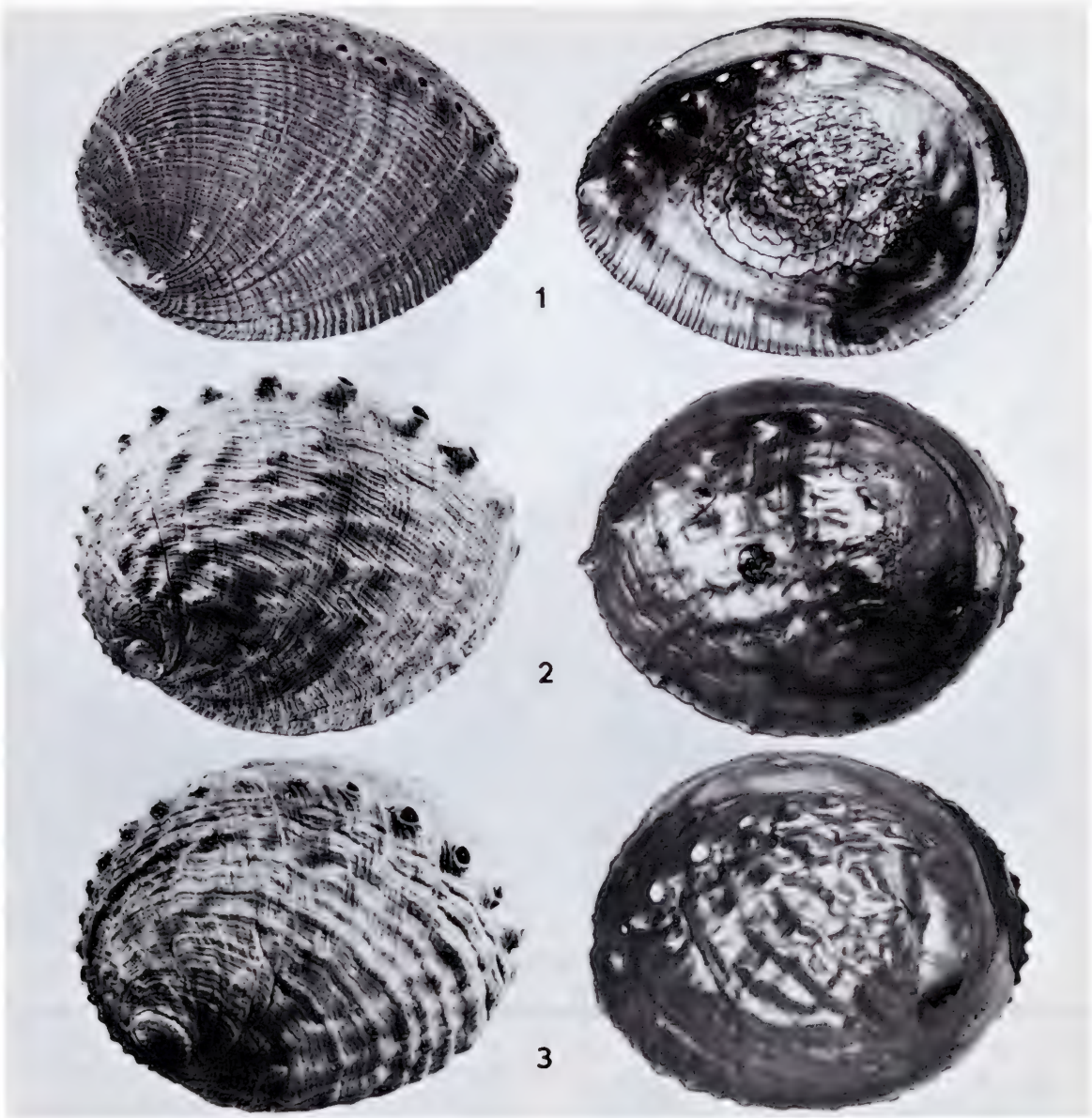

Figure 2. **1,** *Haliotis fulgens*, x .3; **2,** *H. sorenseni*, x .3; **3,** *H. assimilis*, x .5.

1.2 *Haliotis cracherodii* Leach, 1814. BLACK ABALONE. A relatively small species with a nearly smooth black shell. No muscle scar is apparent except in old specimens. The interior is pearly white with only minor iridescence. Five inches is the legal size, but this size is seldom reached in accessible areas in southern California. Strictly intertidal, small specimens are common in crevices or on the undersides of large rocks from the mid-tide level to low water. Range: Mendocino County, California, to southern Baja California.

2.1 *Haliotis fulgens* Philippi, 1845. GREEN ABALONE. Shell relatively low, with 5-7 open holes, which are only slightly raised. Sculpture of broad spiral cords with narrow interspaces. Color usually brown to greenish brown. Muscle scar well developed, interior highly iridescent, chiefly blue with overtones of pink and green. Minimum legal size is 6¼ inches. Young specimens may occasionally be found on the undersides of large rocks at low tide, while larger specimens are found in the immediate subtidal area and seldom occur deeper

than 25 feet. Range: Point Conception, California, to Magdalena Bay, Baja California.

2.2 *Haliotis sorenseni* Bartsch, 1940. WHITE ABALONE. Shell relatively elevated, with 3-5 open holes on tubular projections. Sculpture of weak diagonal undulations over fine spiral ribbing. Color reddish brown, muscle scar area not outlined. Interior pearly white, with weak iridescence of pink and green. Six inches is the legal size. The white abalone usually occurs in relatively deep water, at depths of 70 or more feet, and is most common at the offshore islands. Range: Point Conception, California, to Asuncion Island, central Baja California.

2.3 *Haliotis assimilis* Dall, 1878. THREADED ABALONE. A relatively small, elevated and oval species, with 3-6 open holes on tubular projections. Spiral sculpture characteristic; broad ribs alternate with fine spiral ribs. Color highly variable; red, green, and blue green areas occur, frequently with white splotches on the broad ribs. Muscle scar lacking, interior pearly white, with faint iridescence of pink and green. Legal size five inches, reached by but few specimens. The threaded abalone, like the white abalone, occurs in relatively deep water. Range: Central California to central Baja California.

Family SCISSURELLIDAE

Small, turbinate, white shells, with a multispiral operculum; lip with slit or foramen, used as excurrent opening for water currents. Animal with paired gills. Primitive gastropods, most species occurring offshore.

Sinezona Finlay, 1927

A single species occurs in the eastern Pacific.

3.1 *Sinezona rimuloides* (Carpenter, 1865). Slightly under one mm in height, with three rapidly enlarging whorls. Axial sculpture of raised ridges, base with spiral lirae. Umbilical chink broad, slit band with elongate fissure. Relatively common in gravel at low tide and in the sublittoral zone under kelp. Range: Farallon Islands, California, to Iquique, Chile.

Family FISSURELLIDAE

The keyhole limpets have flattened, oval shells with an apical excurrent opening. Early stages have a spiral shell which is lost as the size of the aperture increases, leaving the mature shell secondarily symmetrical. The muscle scar is horseshoe shaped with an anterior opening. Sculpture consists primarily of radial ribbing.

Diodora Gray, 1821

Keyhole limpets with the internal callus surrounding the fissure having a squared-off posterior end. Sculpture cancellate.

3.2 *Diodora aspera* (Rathke, 1833). ROUGH KEYHOLE LIMPET. Shell heavy and elevated with a nearly circular aperture just anterior to center. Sculpture of coarse, rough radial ribs, every fourth one enlarged, concentric sculpture weaker. Color, grayish white, often with radiating bands of gray. Small specimens reaching a length of 25-30 mm are uncommon in the intertidal zone in southern California, but much more abundant in the northern part of the range, where individuals may attain 70 mm. Range: Afognak Island, Alaska, to Camalu, northern Baja California.

3.3 *Diodora arnoldi* McLean, 1966. Smaller than *D. aspera*, with finer cancellate sculpture. The sides of the shell are nearly parallel and the posterior slope is usually convex or rounded. The fissure is oval and is approximately one-third the length of the shell from the front margin. Color, white, usually with radiating gray bands. Length, 20 mm. Exclusively sublittoral, not uncommon on the undersides of rocks below a depth of 30 feet. Range: Crescent City, California, to San Martin Island, northern Baja California. Listed in older literature as *Diodora murina*, an unavailable name.

Megathura Pilsbry, 1890

The genus is monotypic, characterized by a large shell, nearly covered by the mantle.

3.4 *Megathura crenulata* (Sowerby, 1825). GIANT KEYHOLE LIMPET. Largest of the California keyhole limpets, attaining a length of more than 100 mm. The shell is only slightly elevated, with a large oval aperture

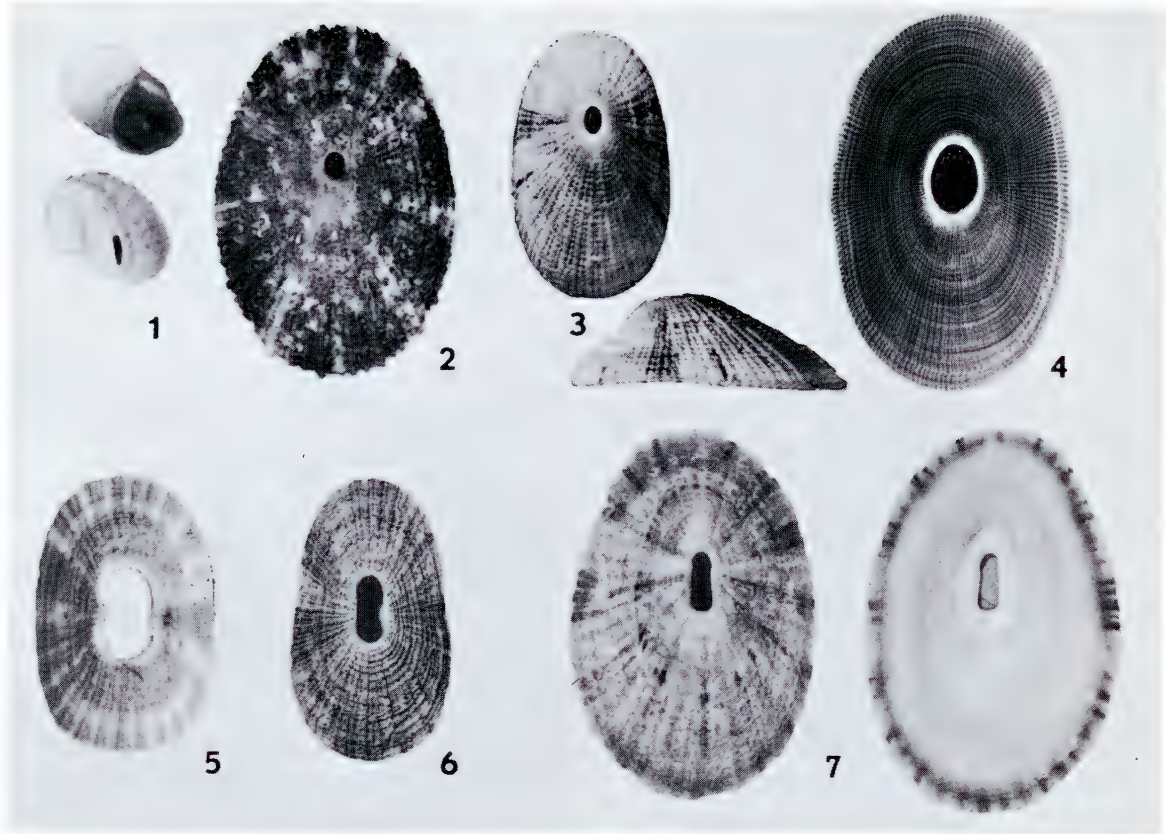

Figure 3. **1,** *Sinezona rimuloides,* x 15; **2,** *Diodora aspera,* x 1.5; **3,** *D. arnoldi,* x 2; **4,** *Megathura crenulata,* x .5; **5,** *Megatebennus bimaculatus,* x 2; **6,** *Lucapinella callomarginata,* x 1.5; **7,** *Fissurella volcano,* x 2.

just to the front of center. Sculpture of fine, even cancellate ribbing, edge of shell crenulated. Interior white, outer surface tan, although juvenile shells have a pink cast. The mantle, covering nearly the entire shell, may be solid black or mottled gray. The species is relatively common from low tide to sublittoral depths on rock surfaces, and is especially common on breakwaters. Range: Monterey Bay, California, to Asuncion Island, central Baja California.

Megatebennus Pilsbry, 1890

The genus is characterized by having an animal much larger than the shell and a relatively large fissure. Only one species is known in California.

3.5 *Megatebennus bimaculatus* (Dall, 1871). Two-Spotted Keyhole Limpet. Shell relatively small, attaining 16 mm in length, although 10 mm is average. The shell is elongate with nearly parallel sides, with raised, oval ends. The large, elongate fissure is centrally placed. Sculpture of radiating ribs and fine concentric growth lines. Color, buff with radiating gray bands concentrated at the sides of the fissure. Body color of the animal, yellow, orange, gray, or brown. Although seldom encountered in the intertidal zone in southern California, it may occasionally be found in rocky areas under kelp. Range: Forrester Island, Alaska, to southern Baja California.

Lucapinella Pilsbry, 1890

Keyhole limpets having coarse, imbricate radial sculpture; animal large in proportion to shell. One species occurs in California; three others are known from tropical Panamic waters.

3.6 *Lucapinella callomarginata* (Dall, 1871). FLESHY KEYHOLE LIMPET. Shell elongate, with a markedly narrow anterior end, only moderately elevated. Fissure elongate, broader posteriorly. Sculpture consists of coarse radial ribs and raised concentric lamellae, margin crenulate. Color, whitish with gray radial banding. Length, about 30 mm. The habitat is restricted to lagoons and bays, at low water and below, on pilings or rocks having heavy encrustations of mussels, sponges and tunicates. Range: Morro Bay, California, to southern Baja California.

Fissurella Bruguière, 1789

Keyhole limpets having elevated conical shells, animal able to retract within the shell. Unlike other keyhole limpets with gray and white patterns, the shells are more brightly marked in *Fissurella*. Primarily a tropical group, with intertidal species. Only one Californian species is known.

3.7 *Fissurella volcano* Reeve, 1849. VOLCANO LIMPET. Shell conical with an elongate fissure just anterior to center; sculpture of coarse or low rounded ribbing. Color, pinkish with alternating rays of reddish black; interior with a green suffusion, a pink line bordering the callus. Length, 20-35 mm. Strictly an intertidal species, it is most abundant at the mid-tide level on the undersurfaces of boulders. Smaller specimens with rough sculpture occur in more exposed habitats. Range: Crescent City, California, to Magdalena Bay, Baja California.

Family ACMAEIDAE

True limpets, having cap-shaped shells, non-nacreous interiors, horseshoe-shaped muscle scars, open in front. These animals have a single gill in the mantle cavity. Acmaeid limpets are important grazers on rocks in the intertidal zone. The radula is a most important character in generic classification and is useful in species determinations.

Acmaea Eschscholtz, 1833

White or pink-rayed shells, with nearly central apex. They live in the low intertidal and sublittoral zones and feed with a specially adapted radula upon coralline algae.

4.1 *Acmaea mitra* Rathke, 1833. WHITE-CAP LIMPET. Shell white, elevated, apex just anterior to center, nearly straight sides, lacking radial sculpture. Large specimens attain a length of 35 mm and a height of 30 mm. Abundant at low tide in the northern part of the range, small specimens have been found, but rarely, at low tide and in the sublittoral along the Palos Verdes Peninsula in Los Angeles County. Range: Aleutian Islands, Alaska, to San Martin Island, northern Baja California.

4.2 *Acmaea funiculata* (Carpenter, 1864). Similar to *A. mitra*, but smaller and with prominent radial ribs. Average specimens are 20 mm in length, 10 mm high. Strictly sublittoral throughout its range, on rocky bottoms in Southern California below a depth of about 80 feet. Range: Shumagin Islands, Alaska, to Magdalena Bay, Baja California.

4.3 *Acmaea rosacea* Carpenter, 1864. ROSY LIMPET. Shell small, thin, apex one-third the length of the shell from the front margin. Posterior face convex, surface smooth or with fine radial ribs. Color, pink, with whitish rays or dots. Length, 8 mm, height, 3.5 mm. Occasionally found at low tide, relatively common in sublittoral depths on the undersides of small, smooth rocks or loose clam valves. Range: Ketchikan, Alaska, to San Geronimo Island, northern Baja California.

Collisella Dall, 1871

Shell with apex well anterior to center, posterior slope convex, shell color variegated, never pink. Individuals generally inhabit only the intertidal zone. Although previous authors have regarded *Collisella* as a subgenus of *Acmaea*, it is here treated as a valid genus, based on its radular, shell, and ecological differences. Many species occur on the west coasts of North and South America.

4.4 *Collisella pelta* (Rathke, 1833). SHIELD LIMPET. Shell large, heavy, elevated, with convex sides; sculpture of irregular radial ribs of varying strength, but sometimes smooth. Color usually brownish with lighter rays, interior white with a blue cast. Large specimens from the northern part of the range may reach 40 mm, but most southern Califor-

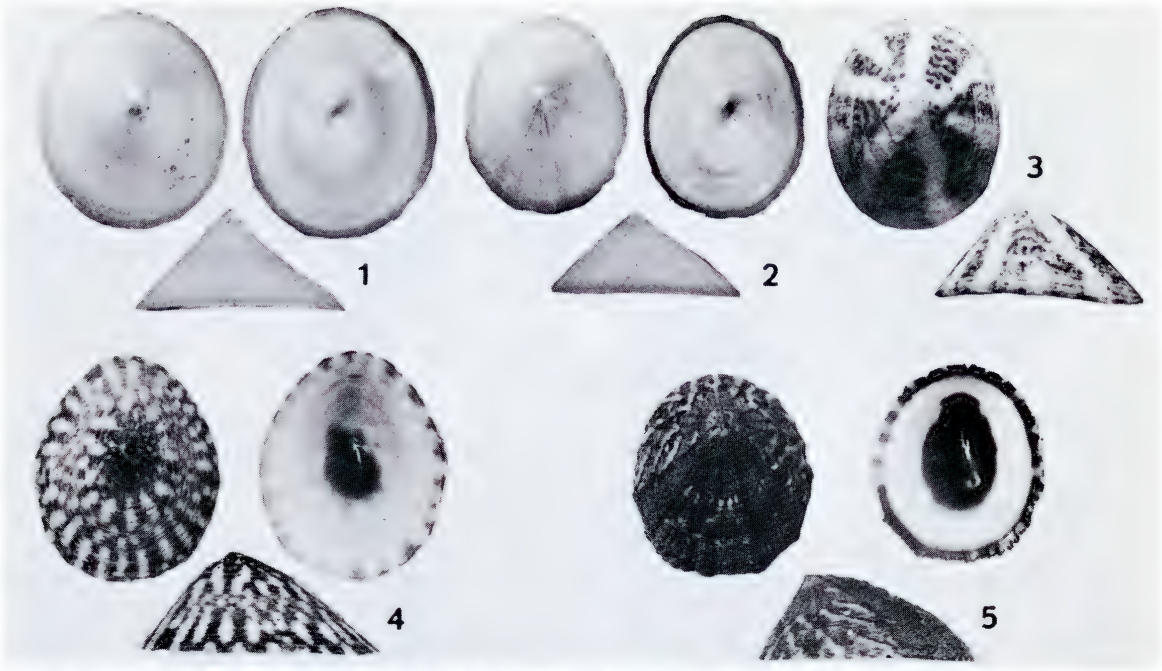

Figure 4. **1,** *Acmaea mitra,* x 1; **2,** *A. funiculata,* x 1; **3,** *A. rosacea,* x 5; **4,** *Collisella pelta,* x 1; **5,** *C. digitalis,* x 1.

nian specimens are about 25 mm in length and have subdued sculpture. Fairly common from the low to midtide level on rocky reefs. Solid black specimens with weak ribbing occur on the stipes or holdfasts of the kelp *Egregia.* Range: Aleutian Islands, Alaska, to Rosario Bay, northern Baja California. Synonym, *C. cassis* (Rathke).

4.5 *Collisella digitalis* (Rathke, 1833). FINGERED LIMPET. Apex close to anterior margin, sometimes overhanging the edge of the shell, posterior face of shell convex; sculpture of radiating ribs, which are strongest on the posterior slope. Color, olive green, with white maculations or dots. Interior bluish white with an irregular brown stain in the center. Length, 15-30 mm. Highly variable in color and position of the apex, it is abundant on vertical faces in the upper intertidal and splash zones, never submerged in tidepools. Range: Aleutian Islands, Alaska, to southern Baja California.

5.1 *Collisella scabra* (Gould, 1846). ROUGH LIMPET. Shell thick, low, apex about one-third the shell length from the front. Ribs strong in all directions, projecting at the shell margin, interspaces nearly as broad as ribs. Color, olive green, surface of ribs often white. Interior white, central area with irregular brown markings. Length, 20-33 mm. Common on rocky reefs at about the midtide level. Range: Cape Arago, Oregon, to southern Baja California.

5.2 *Collisella conus* (Test, 1945). Similar to *C. scabra* but smaller, more conical, with ribs projecting only slightly at the margins. The light colored ribs are narrow, interspaces broader than ribs. Color, greenish-brown, with blue dots or streaks; interior bluish, central area solid brown. Length, 12-19 mm. Common on boulders and rocky reefs in the upper intertidal zone. Range: Point Conception, California, to southern Baja California.

5.3 *Collisella limatula* (Carpenter, 1864). FILE LIMPET. Shell large, low, apex about one-third the shell length from the front margin. Sculpture of numerous fine, scaly ribs. Two color forms occur, a buff yellow and greenish brown, usually with white tessellations. Interior bluish white, margin dark, apical area with an irregular brown stain. Length, 30-45 mm. Abundant from the mid to lower

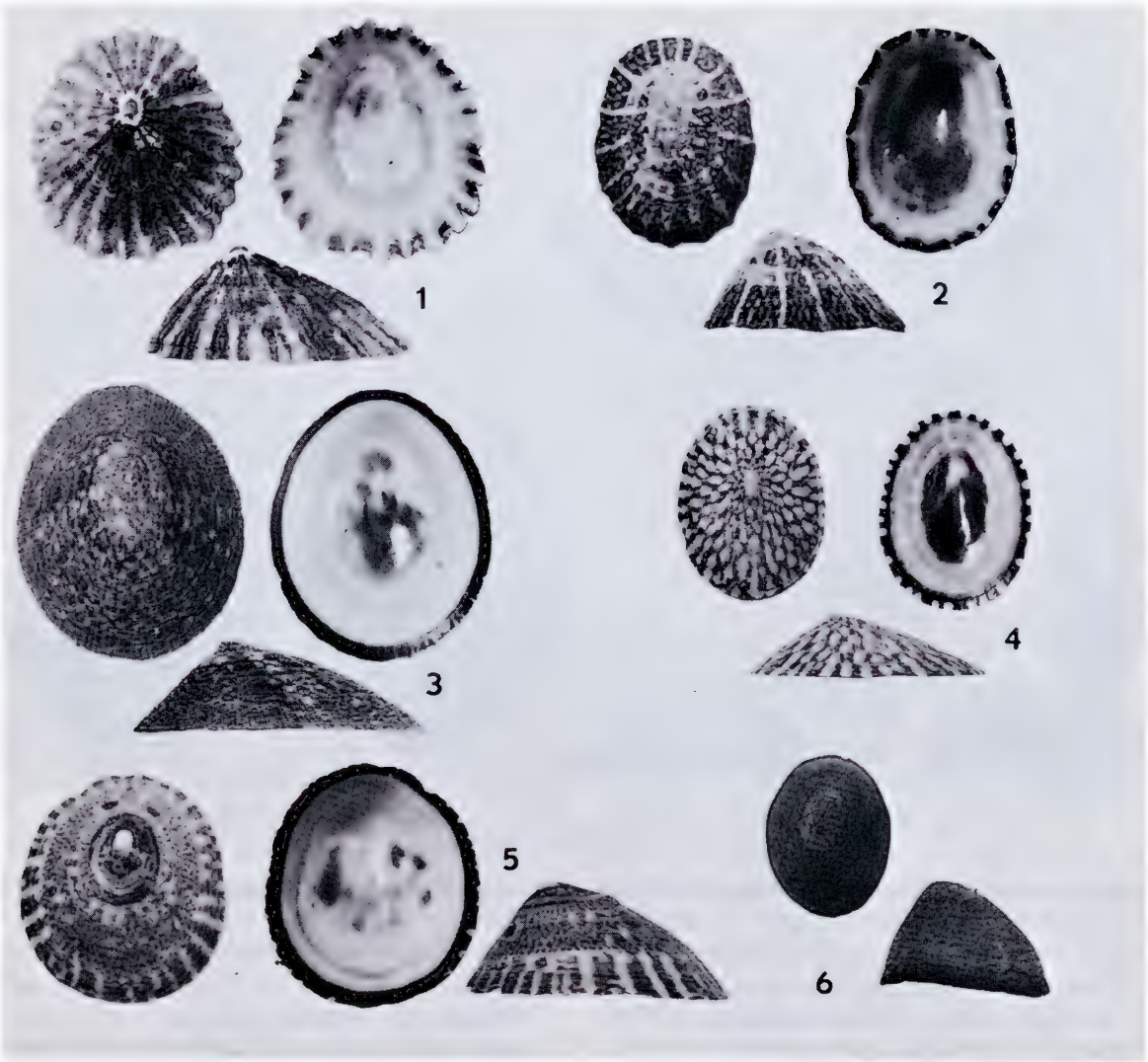

Figure 5. **1,** *Collisella scabra,* x 1; **2,** *C. conus,* x 2; **3,** *C. limatula,* x 1; **4,** *C. ochracea,* x 1.5; **5,** *C. strigatella,* x 1.5; **6,** *C. asmi,* x 2.

tidal levels. Range: Newport, Oregon, to southern Baja California.

5.4 *Collisella ochracea* (Dall, 1871). Thin shelled, low, apex one-third the shell length from the front margin, sculpture of fine radial ribs. Color, buff or olive with white tessellate pattern. Interior bluish white, with irregular brown markings in center. Length, 16-27 mm. Not uncommon on undersurfaces of small rocks at low tide and in sublittoral depths under kelp. This is one of the few species of *Collisella* occurring in the sublittoral zone. *Range*: Aleutian Islands, Alaska, to Cedros Island, central Baja California.

5.5 *Collisella strigatella* (Carpenter, 1864). Shell thick, of medium height; apex directed forward, about one-third the length of shell from front margin; posterior face of shell convex. Surface smooth, apex usually eroded to white; color, olive green with bluish white tessellations, drawn out at the edge. Interior bluish white with irregular brown markings in center, margin well defined, reflecting the outer pattern. Length, 15-18 mm. Common in the middle intertidal zone in rocky areas protected from the open surf. Range: Vancouver Island, British Columbia, to Cape San Lucas, Baja California, and in the Gulf of

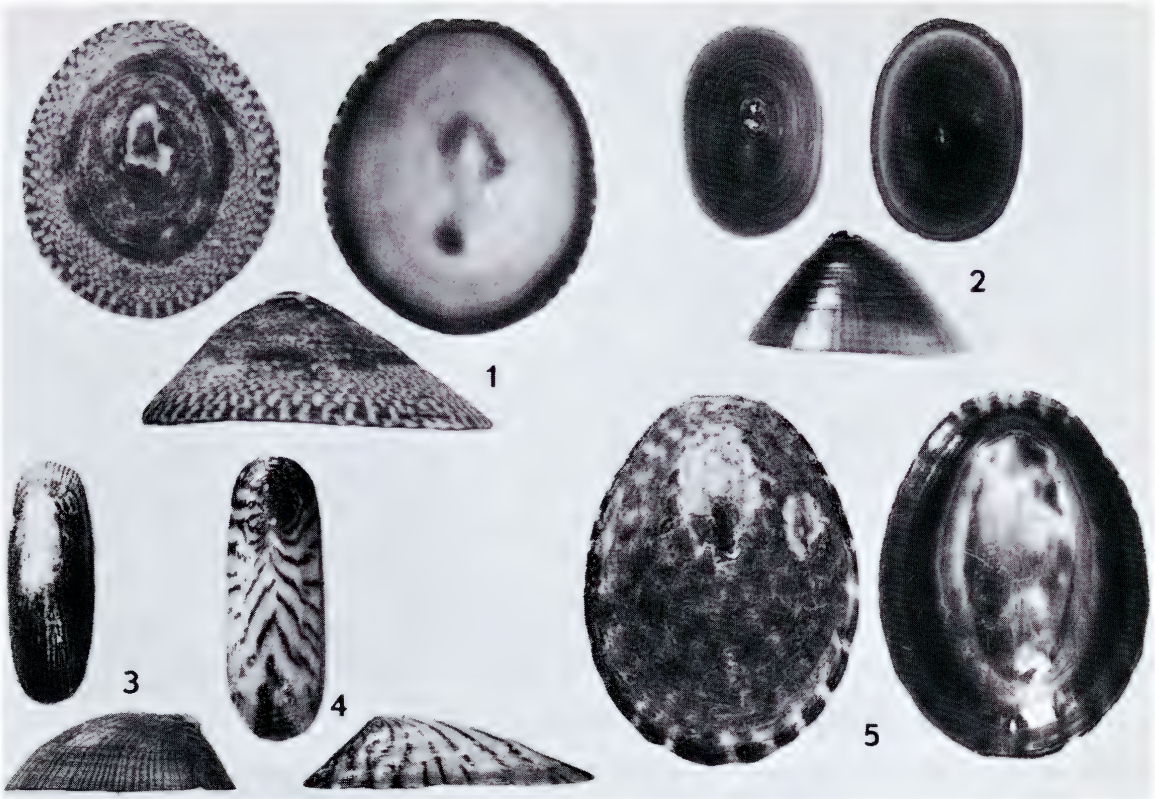

Figure 6. **1,** *Notoacmea fenestrata*, x 1.5; **2,** *N. insessa*, x 1.5; **3,** *N. paleacea*, x 4; **4,** *N. depicta*, x 4; **5,** *Lottia gigantea*, x 1.

California at Guaymas. I regard *Acmaea paradigitalis* Fritchman, 1960, a synonym.

5.6 *Collisella asmi* (Middendorff, 1847). Shell small, elevated, with a dark brown eroded surface and brown interior. Length, 8-11 mm, height, 5-8 mm. This limpet is always attached to living *Tegula funebralis* or *T. gallina*, feeding upon microscopic algae on the host shell. They can move from one host to another. Range: British Columbia to southern Baja California.

Notoacmea Iredale, 1915

Notoacmea is distinguished from *Collisella* by a small but consistent structural difference in the radula. Shells are not heavily ribbed, as are some species of *Collisella*. The genus is widely distributed and occurs in South Australia and New Zealand, where *Collisella* is not present. The species are primarily intertidal, as in *Collisella*. The best known species are *Notoacmea scutum* (Rathke, 1833), and *N. persona* (Rathke, 1833), which occur north of Point Conception.

6.1 *Notoacmea fenestrata* (Reeve, 1855). Shell thin, of moderate height, apex two-fifths of the shell length from the front margin, all sides convex, nearly smooth but with microscopic radial sculpture. The apex is usually eroded to a brown base. Color, olive with white tessellations, interior blue with a brown suffusion throughout, apical area with irregular brown stain. Length, 17-26 mm. Common on reef rocks and boulders adjacent to loose sand, middle to lower tidal zones. Easily confused with *C. strigatella*, from which it differs in being larger, having a brown suffusion in the interior, and an apex eroding to brown. Range: Shumagin Islands, Alaska, to Rancho Socorro, northern Baja California.

6.2 *Notoacmea insessa* (Hinds, 1843). SEAWEED LIMPET. Shell thin, elevated, sides nearly parallel, apex one-third the shell length

from the front margin, all sides convex. Surface shiny and smooth except for fine striae; color, dark brown, usually with small white dots near apex, interior dark brown. Length, 14-19 mm. Common on the stipes and holdfasts of the feather-boa kelp, *Egregia*, which is attached to rocks at the low tide level. The limpets feed directly on the kelp, forming deep scars and eventually destroying it. Range: Wrangell, Alaska, to Magdalena Bay, Baja California.

6.3 *Notoacmea paleacea* (Gould, 1853). Shell small and thin, with sides parallel, apex one-fourth the shell length from the front margin, directed forward. Sculpture of microscopic radial ribs. Color, brown, interior bluish white. Length, 6-10 mm, width, 2-3 mm. Common at low tide on the narrow-bladed eelgrass *Phyllospadix* along the open coast. The animal feeds on superficial algae, not the eelgrass itself. Range: Vancouver Island, British Columbia, to Camalu, northern Baja California.

6.4 *Notoacmea depicta* (Hinds, 1842). Shell similar to that of *N. paleacea* but larger and lacking radial sculpture. Color, white, with pattern of brown lines diverging from the apex and mid-dorsal line, anterior face of shell brown. Length, 12 mm, width, 4 mm. The species occurs only on the blades of eelgrass in protected bays and lagoons. Range: San Pedro, California, to southern Baja California.

Lottia Gray, 1833

A monotypic genus. Anatomically different from *Collisella* in having an accessory gill structure, known as the branchial cordon, a series of flaps on the mantle margin except in front of the head. The radula is similar to that of *Collisella*.

6.5 *Lottia gigantea* Sowerby, 1834. Owl Limpet. Shell large, low, apex one-fifth the shell length from the front margin. Surface with brown and whitish maculations, brown areas raised relative to lighter areas. Interior dark, owl-shaped area within muscle scar well defined, bluish or dark colored. Length, 40-90 mm, but most southern California specimens are 40-50 mm in length. Common in the upper intertidal or splash zone on rocks exposed to heavy surf. Range: Neah Bay, Washington, to Turtle Bay, central Baja California.

Family TROCHIDAE

The top-shells are conical with a nacreous interior, rounded aperture, and horny, multispiral operculum. The animal has epipodial tentacles along the sides of the foot, having a sensory function. Numerous genera are recognized.

Calliostoma Swainson, 1840

Spiral sculpture with fine beading; color patterns variegated, brilliantly iridescent within.

7.1 *Calliostoma annulatum* (Lightfoot, 1786). Purple Ringed Top Shell. Nearly flat-sided with beaded spiral cords. Color, bright golden yellow with a purple band at the periphery and adjacent to the columella. Length, 10-30 mm. Characteristically a more northern form, often common on the blades of giant kelp in northern California; small specimens are found by divers on bottom rocks in southern California. Range: Forrester Island, Alaska, to San Geronimo Island, northern Baja California.

7.2 *Calliostoma canaliculatum* (Lightfoot, 1786). Channeled Top Shell. Shell white to buff with raised spiral ribs, interspaces brownish, a small blue stain adjacent to columella. Height, 15-35 mm. Another northern species, small specimens may occasionally be found on sublittoral rocky bottoms. Range: Sitka, Alaska, to Camalu, northern Baja California. Synonym, *C. dolarium* (Holten).

7.3 *Calliostoma gemmulatum* Carpenter, 1864. Gem Top Shell. Shell elevated, with convex whorls and a deeply impressed suture. Two heavily beaded spiral cords stand out on the early whorls, four additional cords arise on later whorls. Color, olive green with darker longitudinal markings. Height, 15-20 mm. Relatively uncommon in rocky areas at low tide. Range: Cayucos, California, to southern Baja California.

7.4 *Calliostoma gloriosum* Dall, 1871. Glorious Top Shell. Shell elevated, with

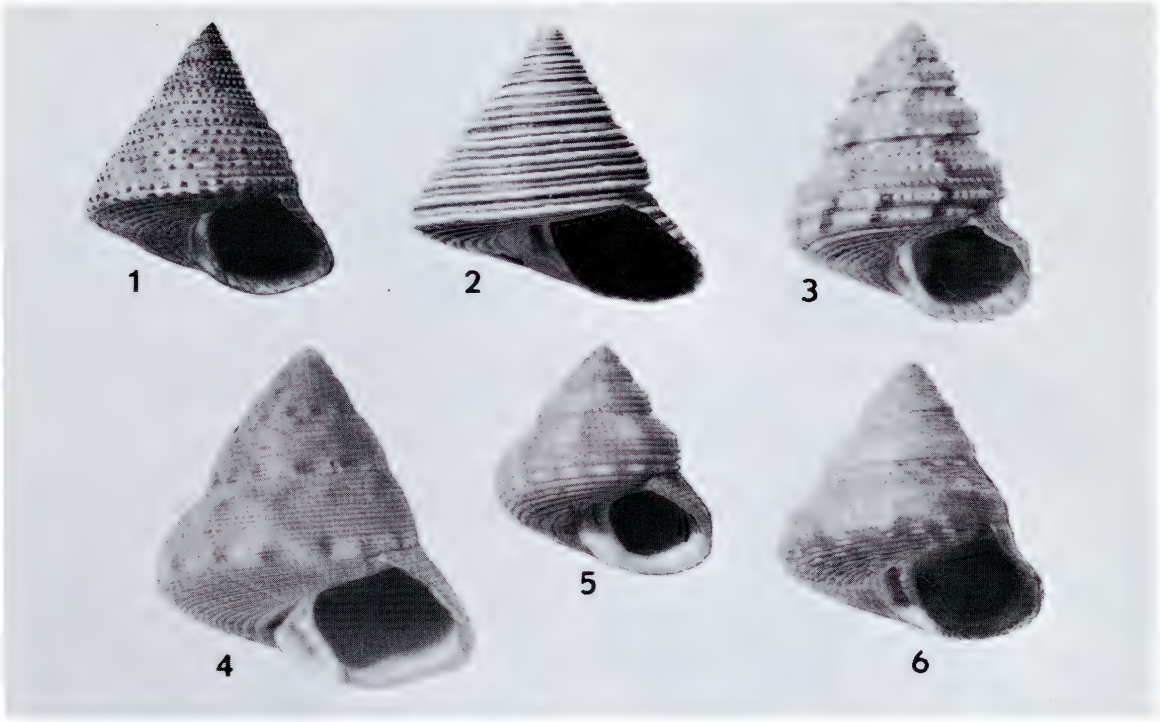

Figure 7. **1,** *Calliostoma annulatum*, x 1.5; **2,** *C. canaliculatum*, x 1; **3,** *C. gemmulatum*, x 1.5; **4,** *C. gloriosum*, x 1.5; **5,** *C. supragranosum*, x 2; **6,** *C. tricolor*, x 1.5.

moderately convex whorls and impressed suture. Sculpture of fine spiral ribs, showing faint beading on upper part of whorl, base angulate, columella white. Color, drab orange to olive with regular brown axial markings. Height, 15-25 mm. An offshore species, relatively uncommon on rocky bottoms under kelp at depths of 50 feet or more. Range: San Francisco, California, to the Coronado Islands, northern Baja California.

7.5 *Calliostoma supragranosum* Carpenter, 1864. GRANULOSE TOP SHELL. A small species having fine spiral cords that are strongly beaded in the early whorls. Color, yellowish brown, with irregular lighter mottling. Height, 8-13 mm. Occasionally common in rocky areas in the lower intertidal and in sublittoral zones. Range: Monterey Bay, California, to Asuncion Island, southern Baja California. I regard *Calliostoma splendens* Carpenter a snyonym.

7.6 *Calliostoma tricolor* Gabb, 1865. THREE COLORED TOP SHELL. Shell with shouldered whorls, upper portion of whorl concave; sculpture of fine spiral ribs, beaded on early whorls. Color, yellowish brown with spaced spiral rings of alternating brown and white. Height, 18-22 mm. A relatively uncommon offshore species on rocky bottoms. Range: Santa Cruz, California, to San Martin Island, northern Baja California.

Lirularia Dall, 1909

Minute trochids having variegated color patterns and an umbilical chink.

8.1 *Lirularia acuticostata* (Carpenter, 1864). Whorls rounded, with spiral cords of regular strength and spacing, and fine, close set, axial threads. Color, whitish with gray or brown mottling, some specimens predominantly dark-colored. Height, 3-5 mm. Strictly sublittoral, common in coarse gravel near rocks at the base of kelp. Range: Point Conception, California, to San Martin Island, northern Baja California.

8.2 *Lirularia parcipicta* (Carpenter, 1864). Similar to *L. acuticostata*, but with a strong, angulate basal carina and fewer spiral

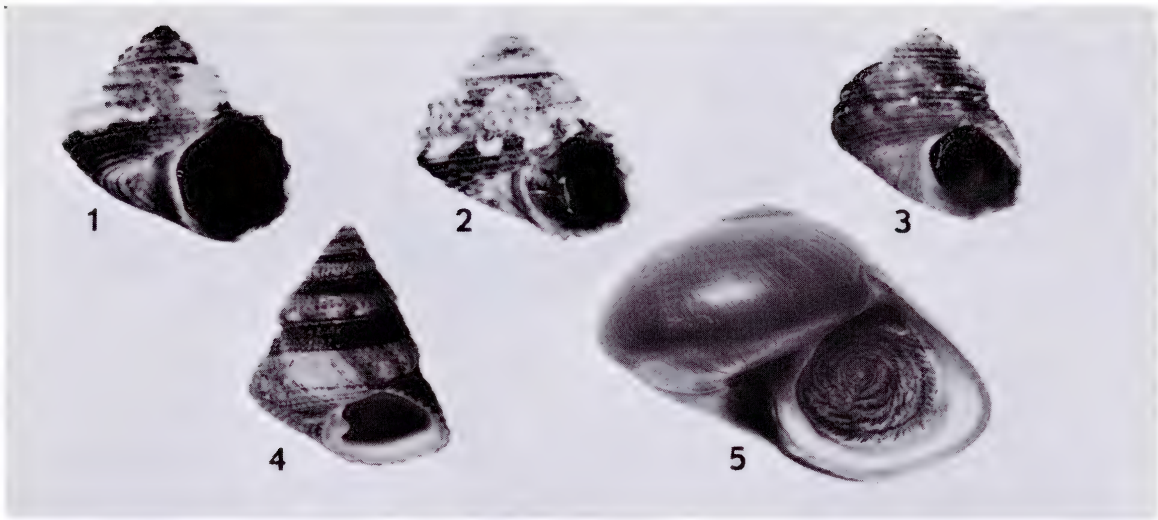

Figure 8. **1,** *Lirularia acuticostata*, x 7; **2,** *L. parcipicta*, x 7; **3,** *L. succinta*, x 7; **4,** *Turcica caffea*, x 1.5; **5,** *Norrisia norrisi*, x 1.

cords on the body whorl and base. Fine axial sculpture as in *L. acuticostata.* Height, 3-5 mm. Not uncommon in coarse gravel in sublittoral zones under kelp. Range: Sitka, Alaska, to San Geronimo Island, northern Baja California.

8.3 *Lirularia succincta* (Carpenter, 1864). Another minute species, differing from *L. acuticostata* in lacking all traces of axial sculpture. The spiral cords are more rounded. Common at times in rocky areas at low tide and in the sublittoral. Height, 3-5 mm. Range: Gulf of Alaska to Santo Tomas, northern Baja California.

Turcica A. Adams, 1854

Flat-sided conical shells with beaded spiral sculpture and two strong folds on the columella. A single species occurs in California.

8.4 *Turcica caffea* Gabb, 1865. Whorls flat sided, with deeply impressed sutures, beaded spiral cords on sides and base; two strong columellar folds. Tan, with lighter colored beads and darker points between beads. A color form has a dark spiral band on the upper part of the whorl. Height, 15-28 mm. Uncommon below 50 feet, and dredged in deeper water. Range: Monterey, California, to Santo Tomas, northern Baja California.

Norrisia Bayle, 1880

A monotypic genus, known only from the following species. Characterized by its spirally tufted operculum.

8.5 *Norrisia norrisi* (Sowerby, 1838). Norris' Top-Shell. Shell solid, broader than high, with smooth, rounded whorls and a deep umbilicus. Color, chestnut brown, black near the umbilicus, columella tinged with green. The early juvenile shell is bicarinate, with white mottling. Operculum spirally tufted. Large shells measure 45 mm in height, 55 mm in diameter. The living animals are bright red and are common on kelp and other brown algae. Often found with slipper limpet, *Crepidula norrisiarum*, attached to the shell. Range: Point Conception, California, to Asuncion Island, central Baja California.

Tegula Lesson, 1835

Solid shells, variously colored, smooth or sculptured, distinguished in having one or more denticles at the base of the columella.

9.1 *Tegula aureotincta* (Forbes, 1852). Gilded Tegula. A moderately elevated species, dark gray or greenish, with an orange stain in the umbilical area. Sculpture of strong spiral cords on the base, weaker cords on the body whorl, crossed by diagonal ridges.

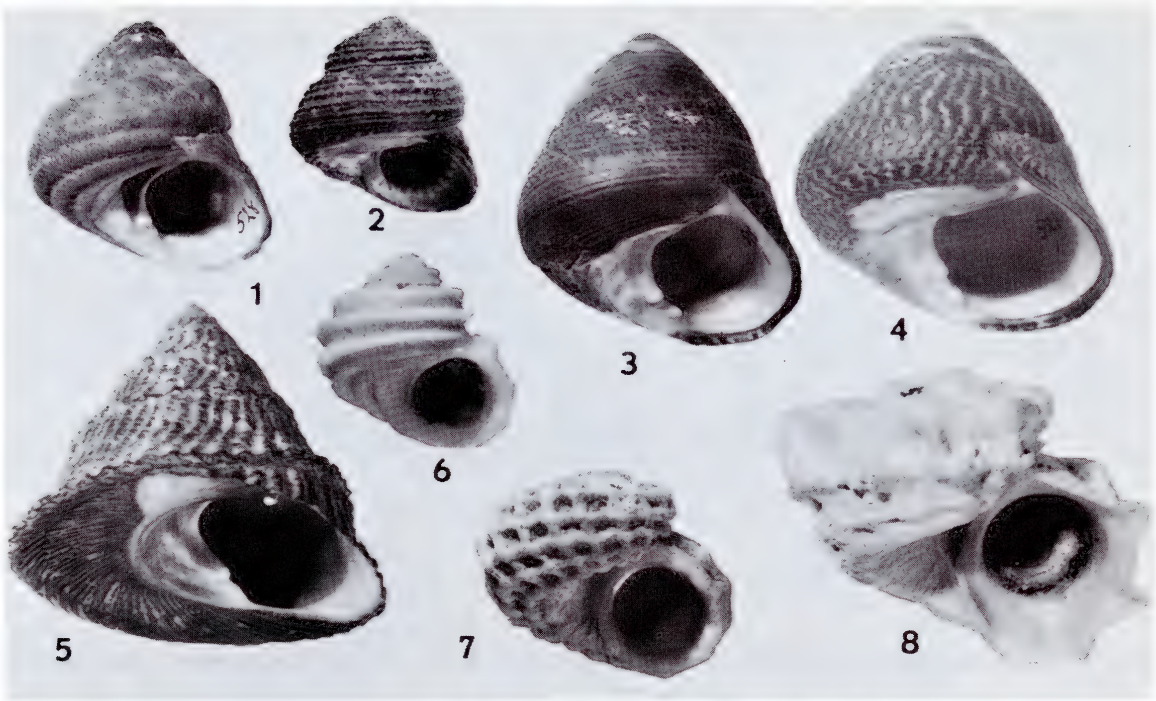

Figure 9. **1,** *Tegula aureotincta*, x 1; **2,** *T. eiseni*, x 1; **3,** *T. fenebralis*, x 1; **4,** *T. gallina*, x 1; **5,** *T. regina*, x 1; **6,** *Parviturbo acuticostatus*, x 10; **7,** *Liotia fenestrata*, x 8; **8,** *Macrarene cookeana*, x 1.5.

Height, 20-40 mm. Not uncommon in rocky areas at low tide and in depths accessible to divers. Range: Ventura County, California, to Magdalena Bay, Baja California.

9.2 *Tegula eiseni* Jordan, 1936. BANDED TEGULA. Brownish, with rounded whorls, sculpture of numerous, evenly spaced spiral ridges that are coarsely beaded. Base deeply umbilicate, usually eroded in advance of the aperture. Height, 20-25 mm. Common at low tide on rocks and in sublittoral zones under kelp. Range: Los Angeles County, California, to Magdalena Bay, Baja California. Listed in older works as *T. ligulata* (Menke), a name applicable only to a related Panamic species.

9.3 *Tegula funebralis* (A. Adams, 1855). BLACK TEGULA. A solid black shell with weak spiral sculpture on the body whorl and base, characterized by a narrow, scaly band below the suture. Base with a broad white area adjacent to the columella. Large specimens reach 50 mm, but most are 25 mm in height. Strictly intertidal, abundant in rocky areas at the midtide level. Range: Vancouver Island, British Columbia, to central Baja California.

9.4 *Tegula gallina* (Forbes, 1852). SPECKLED TEGULA. Similar to *T. funebralis*, but lacking a scaly subsutural band and a defined white basal area. Color ranges from gray to green, with axial stripes of white. Height, 20-40 mm. Also limited to the midtidal zone, it occurs in association with *T. funebralis*, and in some areas may be more abundant. Range: Santa Barbara County, California, to Magdalena Bay, Baja California.

9.5 *Tegula regina* (Stearns, 1892). QUEEN TEGULA. A large gray species with flat-sided whorls. Axial ridges form a crenulate base to the whorl, which slightly overhangs the whorl below. Base with raised radiating ridges, corresponding to growth lines. Umbilical area stained with orange, aperture a pearly yellow within. Height, 40-50 mm. A sublittoral species, found on the vertical sides of large boulders, concentrated at a depth of about 30 feet, with fewer individuals at greater depths. North of San Diego it has been found only on the offshore islands. Range: Catalina Island, Cali-

fornia, to Asuncion Island, central Baja California.

Family SKENEIDAE

Small porcelaneous white shells, with corneous multispiral opercula. Differ chiefly from Trochidae in lacking interior nacre.

Parviturbo Pilsbry and McGinty, 1945

Minute shells with strong spiral sculpture, weaker axial sculpture, and an umbilical chink. Other species occur in the Panamic and Caribbean provinces.

9.6 *Parviturbo acuticostatus* (Carpenter, 1864). Shell minute, white, with strong spiral carinae, narrow umbilical chink, and round aperture. Axial sculpture of fine ridges, frequently with coarse axial ribs producing square cancellations on the upper part of the whorl. Height, 2.5 mm. Not uncommon in gravel under kelp. Range: Monterey Bay, California, to the Gulf of California. Previously listed as *Liotia* or *Arene*.

Family LIOTIIDAE

Characterized by a multispiral operculum bearing radiating rows of calcereous beads and spiral tufts. The shell is top-shaped and the interior nacreous.

Liotia Gray, 1847

Known from the following Californian species and a similar species from Chile.

9.7 *Liotia fenestrata* Carpenter, 1864. A small white shell, with nearly flattened spire, heavy radial and axial sculpture forming deep, square pits. Umbilicus deep, aperture round, nacreous within. About 3 mm in height, 4 mm in diameter. Uncommon in gravel under rocks at low tide; more common in the sublittoral zone under kelp. Range: Monterey Bay, California, to San Martin Island, northern Baja California.

Macrarene Hertlein and Strong, 1951

Relatively large, white-shelled species. Several west American species are known, but only one is accessible to divers in southern California.

9.8 *Macrarene cookeana* (Dall, 1918). Shell low-spired, having two spiral carinae per whorl and three strong spiral ridges on the base. Axial ribs large, well spaced, umbilicus deep. Operculum densely tufted. Height, 15-25 mm. Large shells are always heavily encrusted with coralline algae. Uncommon below depths of 70 feet in areas of loose rock, chiefly at the islands. Range: Anacapa Island, California, to Asuncion Island, central Baja California. Previously listed as *Macarene coronadensis* Stohler, 1959. Dall's name was based on a juvenile specimen. It has been listed as *Cyclostrema cookeana*, but a growth series connects the two.

Family TURBINIDAE

Turbinate or top-shaped, with round apertures and nacreous interiors, similar to the Trochidae, except that the operculum is calcareous and thickened.

Homalopoma Carpenter, 1864

Small turbinate shells with a slight denticle at the base of the columella. The calcareous operculum is flattened, and shows a paucispiral pattern on its exterior surface; the interior surface has a multispiral corneous layer.

10.1 *Homalopoma luridum* (Dall, 1885). Shell small, globose, with a variable number of rounded spiral cords on the body whorl and base. Brown, gray, reddish, white-banded, or solid white, it is highly variable in color. Large specimens reach 9 mm, but shells from most southern California populations average 5 mm in height. Common from low tide to sublittoral depths. Range: Sitka, Alaska, to San Geronimo Island, northern Baja California. I regard *Homalopoma carpenteri* Pilsbry a synonym.

10.2 *Homalopoma baculum* (Carpenter, 1864). Similar to *H. luridum*, but with more subdued spiral sculpture, appearing almost smooth. Slightly smaller, reaching only 4 mm in height. The color is less variable, ranging from gray to reddish gray. Strictly intertidal, common on the undersides of rocks in the midtide zone. Range: Monterey Bay, California, to San Martin Island, northern Baja California.

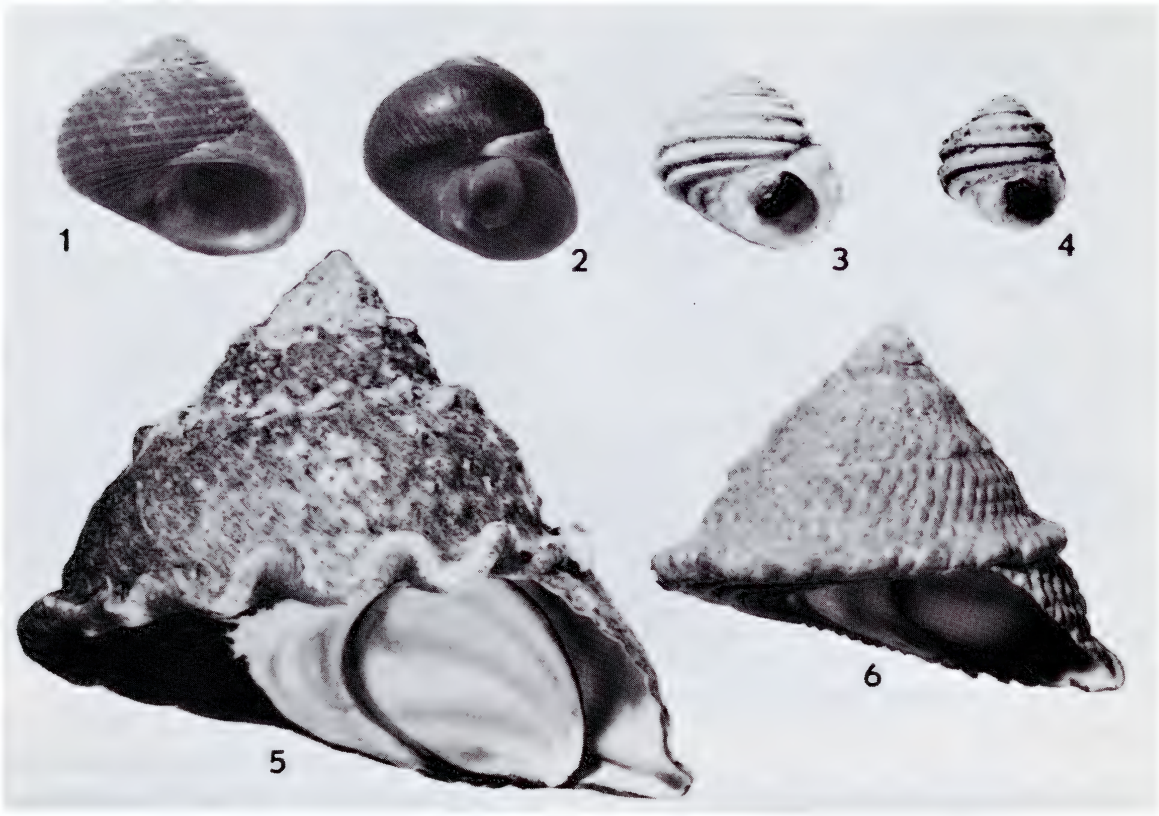

Figure 10, **1,** *Homalopoma luridum*, x 5; **2,** *H. baculum*, x 5; **3,** *H. paucicostatum*, x 5; **4,** *H. fenestratum*, x 5; **5,** *Astraea undosa*, x .7; **6,** *A. gibberosa*, x 1.

10.3 *Homalopoma paucicostatum* (Dall, 1871). Smaller than *H. luridum*, with fewer and more prominent spiral ribs. The columellar denticle is prominent. Red, pink, and white color forms occur. Height, 4 mm. Not uncommon in gravel under kelp, strictly sublittoral. Range: Monterey Bay, California, to San Martin Island, northern Baja California.

10.4 *Homalopoma fenestratum* (Dall, 1919). Similar to *H. paucicostatum* in having about seven prominent spiral cords on the body whorl and base, but having axial ribs that form squarish cancellations. The columellar denticle is strong. Color, white with faint pink dots on the spiral ribs. Height, 3.5 mm. Range: Monterey, California, to San Martin Island, northern Baja California. Do not confuse with *Liotia fenestrata*. It resembles *Parviturbo acuticostatus*, but is larger, shows pink dots and has a columellar denticle.

Astraea Röding, 1798

Large, conical shells, with axial and spiral sculpture, and oval opercula.

10.5 *Astraea undosa* (Wood, 1828). Wavy Turban. Shell large, sculptured with wavy ridges and nodules, base with strong spiral ribs. Operculum with lateral nucleus and strong, spinose ridges. Color, tan under a thick, fibrous periostracum. Small specimens reaching 50 mm in height may be common at low water in rocky areas, while large specimens of 110 mm are found on rocky bottoms, particularly in kelp beds. Range: Point Conception, California, to Asuncion Island, central Baja California. This species is in the subgenus *Uvanilla* Gray, 1850, characterized by the strongly ridged operculum.

10.6 *Astraea gibberosa* (Dillwyn, 1817). Red Turban. Smaller than *A. undosa*, the sculpture on the sides of the whorls is variable,

usually of diagonal folds and small nodes. The periphery may be rounded, angulate, or bear spiny projections. Base with strong spiral cords, operculum smooth with a shallow furrow. Color, reddish brown under a closely adherent periostracum. Height, 30-50 mm. Although the species occurs in shallow water in the northern part of its range, in southern California it lives on rocky bottoms at depths of 70 feet or more. Range: Queen Charlotte Islands, British Columbia, to Magdalena Bay, Baja California. Listed in older works as *A. inaequalis* Martyn. This species is in the subgenus *Pomaulax* Gray, 1850, characterized by the smooth operculum.

Family PHASIANELLIDAE

Like the Turbinidae, the Phasianellids or pheasant shells have a calcareous operculum, but they differ chiefly in having a porcelaneous rather than nacreous interior to the shell.

Tricolia Risso, 1826

Small shells with variegated color patterns, smooth or with spiral sculpture, operculum calcareous, oval, outer surface convex.

11.1 *Tricolia compta* (Gould, 1855). BANDED PHEASANT. Shell large for the genus, high spired, with a rounded periphery and slight umbilical chink. Color, greenish brown, mottled with white and with thin brown lines slanted forward and down. Height, 7-11 mm. Occasionally common on eelgrass in the shallow lagoons of southern California. Range: Mugu Bay, Ventura County, California, to Todos Santos Bay, northern Baja California.

11.2 *Tricolia pulloides* (Carpenter, 1865). Shell similar to *T. pulloides*, but smaller, 4-6 mm in height. Color, chiefly pink, some specimens with a complete or partial pattern of lines as in *T. compta*; others are pink with white blotching. Common on the open coast at low tide and in the shallow sublittoral, in eelgrass or gravel. Range: Puget Sound, Washington, to Cape San Lucas, Baja California. This may be an ecological variant of *T. compta*, but there are size, color, and distributional differences.

11.3 *Tricolia rubrilineata* (Strong, 1928). Shell minute, similar to the previous species, but not exceeding 2.1 mm in height. Color, a uniform pale green with red spiral lines in the direction of growth and white blotching at the shoulder. Common in gravel near eelgrass roots and in the sublittoral under kelp. Range: Los Angeles County, California, to San Martin Island, northern Baja California.

11.4 *Tricolia substriata* (Carpenter, 1864). Shell minute, not exceeding 3.2 mm in height, with fine spiral striae, and a broad umbilicus. Color, highly variable, with brown, white, gray and green mottling. A sublittoral species, living in gravel under kelp. Range: Los Angeles County, California, to the Gulf of California.

Order MESOGASTROPODA

The mesogastropods or "middle gastropods" generally have coiled shells and opercula, although some groups have cap-shaped shells lacking opercula. Apertures are mostly round or oval. Shells in some families may have short anterior canals, but none have long siphonal canals. The typical mesogastropod radula has seven teeth in each row. Feeding is diverse; some graze on algae, some are parasitic, and others are carnivorous.

Family LACUNIDAE

Thin shelled snails, characterized by a shelf-like columella and narrow umbilical chink. Operculum paucispiral. A cool water, northern group.

Lacuna Turton, 1827

Small shells, only one species is common in southern California.

11.5 *Lacuna unifasciata* Carpenter, 1857. ONE-BANDED LACUNA. Small, thin-shelled, high-spired, brownish, angulate base usually bearing a dark brown line, columella white. Height, 5-7 mm. Common in eelgrass and algae at low tide and in the sublittoral under kelp. Range: Monterey, California to Magdalena Bay, Baja California.

Family LITTORINIDAE

The periwinkles are abundant snails of the upper intertidal and splash zones throughout

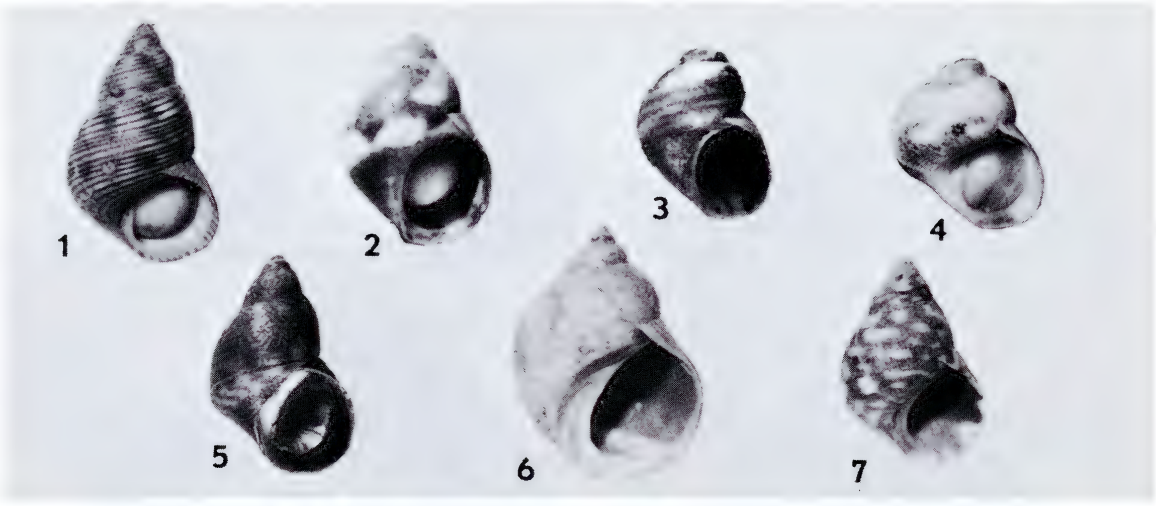

Figure 11. **1,** *Tricola compta*, x 3; **2,** *T. pulloides*, x 6; **3,** *T. rubrilineata*, x 10; **4,** *T. substriata*, x 8; **5,** *Lacuna unifasciata*, x 4; **6,** *Littorina planaxis*, x 2; **7,** *L. scutulata*, x 2.

the world. Shells are few whorled, nonumbilicate, and the operculum is corneous and paucispiral.

Littorina Ferussac, 1822

Shells are smooth or spirally sculptured.

11.6 *Littorina planaxis* Philippi, 1847. ERODED PERIWINKLE. Shell usually eroded, brownish, with whitish tesallations. Columella broad, light colored, continuous with an adjacent, dark, worn area on the body whorl. Aperture brown, a white band within at the base. Height, 13-18 mm. Abundant on rocky reefs in the splash zone. Range: Puget Sound, Washington, to Magdalena Bay, Baja California.

11.7 *Littorina scutulata* Gould, 1849. CHECKERED PERIWINKLE. Smaller than *L. planaxis*, more slender and lacking the broad columella. The shell is smooth, brownish, occasionally with lighter spiral banding, and white maculations. Height, 8-13 mm. Common in the upper intertidal zone, not extending as high as *L. planaxis*. Range: Kodiak Island, Alaska, to Turtle Bay, Baja California.

Family RISSOIDAE

Minute forms with elevated spire, smooth or variously sculptured, aperture rounded. A few species are large enough to be seen on the undersides of rocks, but most are more easily collected from gravel samples, taken at low tide or in the sublittoral zone.

Alvinia Monterosato, 1884

Minute white or brown shells characterized by cancellate sculpture. West American species were assigned to the European genus *Alvania* in older literature.

12.1 *Alvinia aequisculpta* (Keep, 1887). Although this species attains but a height of 3.3 mm, it is unusually large for the genus. It is white and is characterized by spiral lines on the first 1.5 whorls, three spiral cords on later whorls, with axial sculpture of equal strength, producing strong cancellations. Not uncommon in gravel, from low tide to the sublittoral. Range: Monterey Bay, California, to Todos Santos Bay, northern Baja California.

12.2 *Alvinia cosmia* (Bartsch, 1911). Similar to *A. aequisculpta*, white, with spiral lines on the nuclear whorls, and strong cancellate sculpture. It differs in being smaller, 2.2 mm maximum height, and in having only two spiral cords per whorl. Found with the preceding species. Range: Los Angeles County, California, to San Martin Island, northern Baja California.

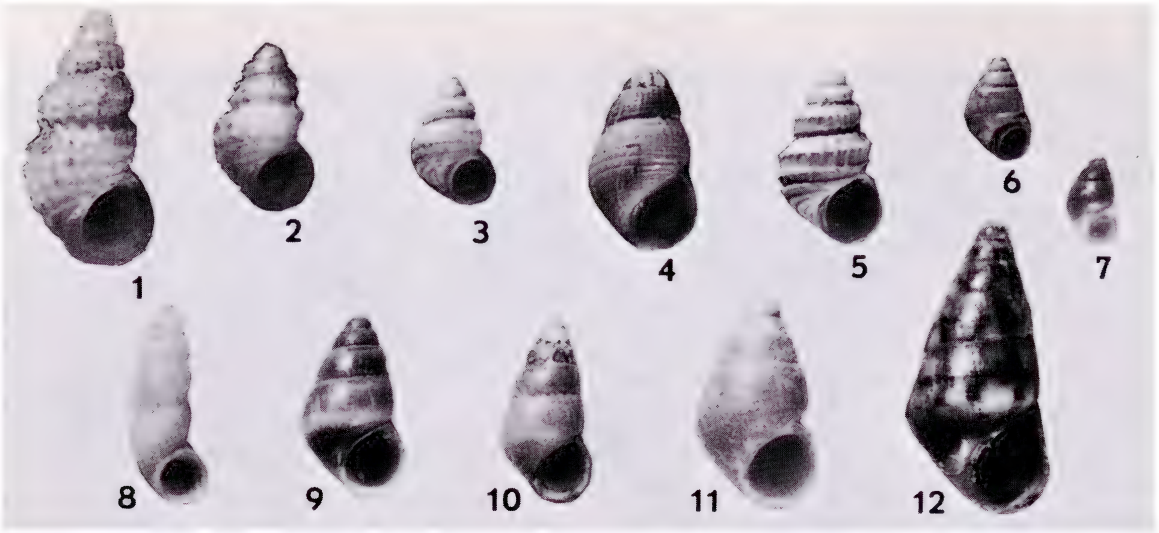

Figure 12. **1,** *Alvinia aequisculpta*, x 10; **2,** *A. cosmia*, x 10; **3,** *A. oldroydae*, x 10; **4,** *A. compacta*, x 10; **5,** *A. purpurea*, x 10; **6,** *Amphithalamus inclusus*, x 10; **7,** *A. tenuis*, x 10; **8,** *Nannoteretispira keyseyi*, x 15; **9,** *Barleeia californica*, x 10; **10,** *B. haliotiphilia*, x 10; **11,** *B. subtenuis*, x 10; **12,** *B. acuta*, x 10.

12.3 *Alvinia olroydae* (Bartsch, 1911). Shell minute, whitish, nuclear whorls smooth, sculpture cancellate, spiral cords three per whorl. Common in sublittoral gravel. Height, 1.5 mm. Range: Monterey Bay, California, to Asuncion Island, central Baja California.

12.4 *Alvinia compacta* (Carpenter, 1864). Shell minute, brownish, with dense axial and spiral sculpture producing cancellations. Height, 2.2-2.7 mm. Common in gravel, low tide to sublittoral. Range: Aleutian Islands, Alaska, to San Martin Island, northern Baja California. I regard *Alvinia acutelirata* Carpenter a synonym.

12.5 *Alvinia purpurea* (Dall, 1871). Shell brownish, with two spiral cords per whorl plus five on the base, axial sculpture producing square cancellations on upper half of shell. Height, 2.2 mm. Not uncommon in sublittoral gravel. Range: Monterey Bay, California, to San Martin Island, northern Baja California.

Amphithalamus Carpenter, 1864

Extremely small shells, slightly over 1 mm in length, smooth except for a peripheral carination, inner lip offset from columella, producing a shelflike structure.

12.6 *Amphithalamus inclusus* Carpenter, 1864. With angulate periphery, height, 1.3 mm. Common in gravel under kelp. Range: San Pedro, California, to southern Baja California.

12.7 *Amphithalamus tenuis* Bartsch, 1911. More slender than *A. inclusus*, with a rounded periphery. Height, 1.1 mm. Occurs with *A. inclusus*. Range: Monterey, California, to San Geronimo Island, northern Baja California.

Nannoteretispira Habe, 1961

One species is known from southern California, another from Japan.

12.8 *Nannoteretispira kelseyi* (Bartsch, 1911). Shell minute, whitish, high spired, with a rounded aperture projecting outward. Height, 1.7 mm. Not uncommon in gravel at low tide and in the sublittoral. Range: Palos Verdes Peninsula, California, to Cape San Lucas, Baja California. Previously assigned to *Nodulus*.

Barleeia Clarke, 1853

Small brownish shells, whorls slightly convex, smooth. The minute operculum has a peg-like projection on its inner side.

12.9 *Barleeia californica* Bartsch, 1920. A shiny, light brown shell with a whitish band near the periphery, aperture relatively large. Height, 2.3 mm. Common at low tide and in the sublittoral under kelp. Range: San Pedro, California, to Point Abreojos, central Baja California.

12.10 *Barleeia haliotiphila* Carpenter, 1864. A slender dark brown shell with a slight basal angularity, larger than *B. californica.* Height, 2.5-3 mm. Not uncommon at low tide and in the sublittoral zone in rocky areas. Range: Vancouver Island, British Columbia, to Point Abreojos, central Baja California. I regard *Barleeia oldroydi* Bartsch a synonym.

12.11 *Barleeia subtenuis* Carpenter, 1864. Broader than the two preceding species, color dark brown. Height, 2.0-2.7 mm. Not uncommon at low tide and in sublittoral zones, also common in lagoons. Range: Afognak Island, Alaska, to San Ignacio Lagoon, central Baja California. I regard *Barleeia sanjuanensis* Bartsch a synonym.

12.12 *Barleeia acuta* (Carpenter, 1864). Relatively large, the species has a sharp basal carination, shiny, flat-sided whorls and axial mottling of darker coloration. Height, 3.7-4.0 mm. Range: Queen Charlotte Islands, British Columbia, to Asuncion Island, central Baja California. I regard *Barleeia marmorea* Carpenter and *B. dalli* Bartsch as synonyms. Placed in the subgenus *Pseudodiala* Ponder, 1967, distinguished by size, flat whorls, and angulate periphery.

Rissoina Orbigny, 1840

Small white shells with flaring aperture, usually axial ribbing; some with incised spiral lines. Californian species are uncommon and occur in gravel near rocky areas. Two of the more frequently found species are treated.

13.1 *Rissoina bakeri* Bartsch, 1902. Whorls convex, axial ribs 12 with strong axial threads between. Height, 2.7-2.9 mm. Uncommon in gravel under kelp. Range: Monterey Bay, California, to Coronado Islands, northern Baja California.

13.2 *Rissoina dalli* Bartsch, 1915. Whorls only slightly inflated, nearly smooth, except for fine axial threads. Height, 2.8 mm. Uncommon in gravel at low tide and under kelp. Range: San Pedro, California, to Coronado Islands, northern Baja California.

Family ASSIMINEIDAE

Small shells, nearly smooth, found in marine, brackish or fresh water.

Assiminea Fleming, 1828

Sturdy conical shells with the inner lip forming a thick parietal callus. A single species occurs on the California coast.

13.3 *Assiminea californica* Tryon, 1865. A minute, brown shell with convex whorls, and thickened parietal callus. Height, 3.0-3.3 mm. Abundant at the high tide line on mud under drift debris in lagoons. Range: Vancouver Island, British Columbia, to Estero Punta Banda, northern Baja California. *Assiminea translucens* Carpenter is a synonym.

Family VITRINELLIDAE

Small to minute species, usually white or glassy, low spired or discoidal, with rounded aperture, operculum many whorled.

Vitrinella C. B. Adams, 1850

Small, discoidal, white shells, with rounded whorls, and an open umbilicus.

13.4 *Vitrinella oldroydi* Bartsch, 1907. A small white species with rounded whorls, nearly circular aperture, and a broad open umbilicus. Shells are usually badly eroded, often with the nucleus missing. Diameter, 2.1 mm. Range: Cayucos, California, to Point Abreojos, central Baja California.

Teinostoma A. Adams, 1851

Small discoidal, white shells, with a callus pad covering the umbilical area.

13.5 *Teinostoma supravallatum* (Carpenter, 1864). Glassy white, whorls rounded, with or without a strong carination on the upper part of the whorl, base with a weak carination, columellar pad broad. Height, 1.1 mm; diameter, 1.8 mm. Abundant in gravel from eelgrass roots and the sublittoral. Range: Los Angeles County, California, to San Geronimo Island, northern Baja California. Specimens lacking the carination of the upper part of the whorl have been recognized as *T. invallatum* Carpenter by many authors. The two forms occur together in equal numbers and I regard them as polymorphic forms of the same species.

Vitrinorbis Pilsbry and Olsson, 1952

Extremely minute, flat-spired shells, with strong spiral keels and relatively weaker axial

Figure 13. **1,** *Rissoina bakeri*, x 10; **2,** *R. dalli*, x 10; **3,** *Assiminea californica*, x 10; **4,** *Vitrinella oldroydi*, x 10; **5**, *Teinostoma supravallatum*, x 10; **6,** *Vitrinorbis diegensis*, x 15; **7,** *Truncatella californica*, x 6.

sculpture. One species occurs in California.

13.6 *Vitrinorbis diegensis* (Bartsch, 1907). With a projecting peripheral keel and an upper and lower keel, nearly flat spire, broad umbilicus and fine axial sculpture. One of the smallest species, height, 0.3 mm; diameter, 1.0 mm. Common in gravel under kelp. Range: Monterey Bay, California, to San Martin Island, northern Baja California.

Family TRUNCATELLIDAE

Small shells, early whorls truncated (broken off) and the hole sealed shut. They live just above the high tide line under rocky rubble.

Truncatella Risso, 1826

High spired, whitish shells with axial ribbing.

13.7 *Truncatella californica* Pfeiffer, 1857. Shell small, cylindrical, with numerous axial ribs, lip thickened and early whorls truncated in mature shells. Height, 5.5 mm. May be found in large numbers under rocky rubble above the high tide line on the open coast. Range: Santa Barbara, California, to Magdalena Bay, Baja California. The species is polymorphic, having ribbed and smooth forms. The smooth forms have been called *T. stimpsoni* Stearns, which I regard as a synonym.

Family CAECIDAE

Minute tubular shells. Juvenile shells have a spiral nucleus, which is shed and the hole filled with a rounded or pointed plug. The operculum is multispiral.

Caecum Fleming, 1813

Sculpture consisting of rings, which encircle the tube.

14.1 *Caecum californicum* Dall, 1885. Shell light brown with 30-40 close set rings, aperture thickened. Length, to 3.0 mm. Abundant in gravel in tidepools and near eelgrass, low intertidal and sublittoral zones. Range: Monterey Bay, California, to Magdalena Bay, Baja California.

14.2 *Caecum dalli* Bartsch, 1920. White to tan, with 18-24 round or angulate rings, often with broader interspaces, rings closely spaced at aperture. Highly variable in strength and number of rings. Length, 2.5 mm. Chiefly sublittoral, in gravel under kelp. Range: Monterey Bay, California, to Asuncion Island, central Baja California.

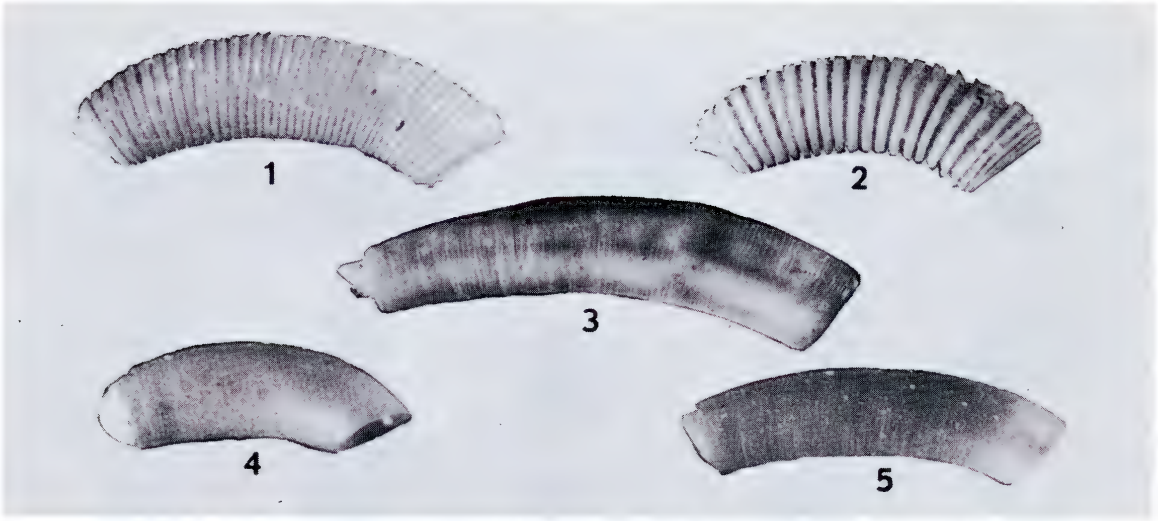

Figure 14. **1,** *Caecum californicum*, x 18; **2,** *C. dalli*, x 18; **3,** *C. crebricinctum*, x 11; **4,** *Fartulum orcutti*, x 18; **5,** *F. occidentale*, x 18.

14.3 *Caecum crebricinctum* (Carpenter, 1864). Relatively large, with numerous fine encircling rings, often with a brown mottled pattern. Length, 5-6 mm. Strictly sublittoral, in gravels under kelp and dredged on sandy bottoms in deeper water. Range: Vancouver Island, British Columbia, to Asuncion Island, Baja California. Placed in the subgenus *Micranellum* Bartsch, distinguished from *Caecum* chiefly in size and in having more numerous rings. This and the preceding species have numerous synonyms.

Fartulum Carpenter, 1857

Shell surface nearly smooth, plug with rounded or blunt tip.

14.4 *Fartulum orcutti* (Dall, 1885). Shell smooth, tan, swollen near aperture, plug tip blunt, aperture oblique. Length, 2.3 mm. Abundant on undersurfaces of stones and debris at high tide mark in protected rocky areas of the open coast. Range: Palos Verdes, California, to San Geronimo Island, northern Baja California.

14.5 *Fartulum occidentale* Bartsch, 1920. Larger than *F. orcutti*, evenly tapering, with a less oblique aperture and a rounder plug. Length, 2.5-3.8 mm. Range: Prince William Sound, Alaska, to Cedros Island, central Baja California.

Family TURRITELLIDAE

Many-whorled, elongate shells, with round aperture and multispiral operculum. Generally sedentary, they lie partially buried on soft bottoms and feed upon detrital material.

Turritella Lamarck, 1799

Shells with tight, regular coiling. One species is common, others occur in the Panamic province.

15.1 *Turritella cooperi* Carpenter, 1864. Cooper's Turret. Shell with two prominent spiral cords per whorl, plus a variable number of cords of lesser strength. Color, light buff with darker axial mottling. Height, 40-55 mm. Common offshore on sand or mud bottoms, at depths of 60 feet or more. Beachworn specimens are frequent. Range: Monterey Bay, California, to Cedros Island, central Baja California.

Vermicularia Lamarck, 1799

Early whorls are tightly coiled as in *Turritella*, but later whorls are irregular, with loose coiling. One species occurs in California, another in the Panamic province.

15.2 *Vermicularia fewkesi* Yates, 1890. Early whorls show two strong spiral ribs, with a third strong basal carina. Beyond a length of 5 mm, the shell is loosely coiled. Small speci-

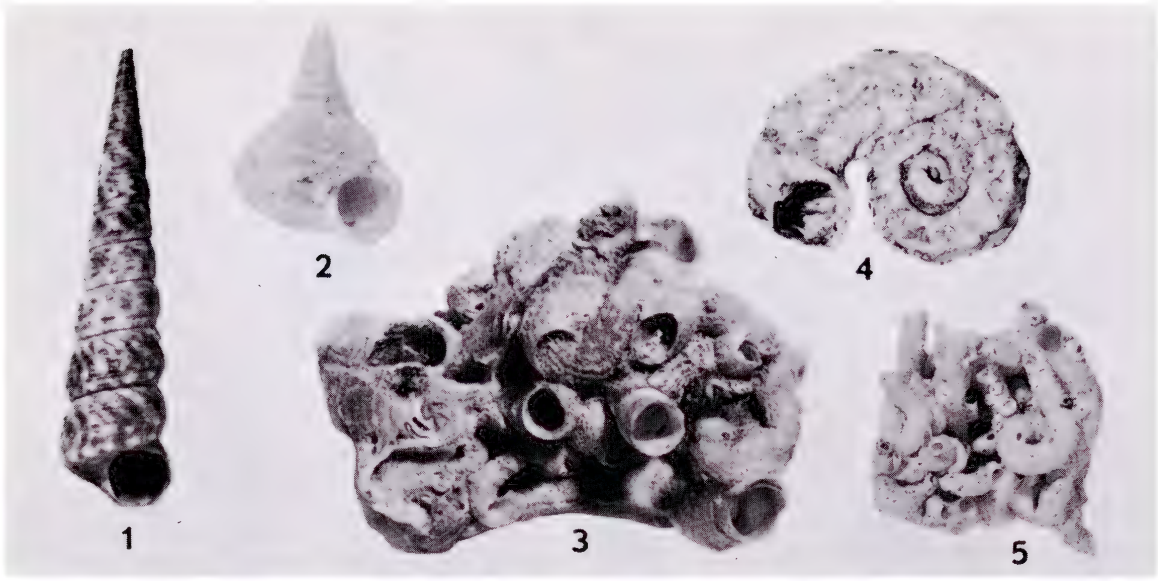

Figure 15. **1,** *Turritella cooperi*, x 1; **2,** *Vermicularia fewkesi*, x 2; **3,** *Serpulorbis squamigerus*, x 1; **4,** *Dendropoma lituella*, x 2; **5,** *Petaloconchus montereyensis*, x 1.5.

mens are not uncommon in sublittoral zones under kelp. Height, 10-15 mm; tube diameter, to 4 mm. Range: Santa Barbara, California, to Cedros Island, central Baja California.

Family VERMETIDAE

The worm shells. Only the nuclear whorls are spirally coiled. Adult whorls emerge at a right angle to the nuclear whorl, attach to the substrate, and assume an irregular growth form.

Serpulorbis Sassi, 1827

Large, loosely coiled, lacking an operculum.

15.3 *Serpulorbis squamigerus* (Carpenter, 1857). Scaled Worm Shell. Individual tubes are longitudinally ribbed, somewhat scaly, and show breakage scars, because the growing ends of the tubes are fragile. Colonies grow in twisted masses attached to wharf pilings, breakwater rocks, and upper surfaces of stones in some protected intertidal areas. Tube diameter, 6-9 mm. Range: Santa Barbara, California, to Point Abreojos, central Baja California. Listed in older works as *Aletes squamigerus*.

Dendropoma Mörch, 1861

Vermetids having a multispiral operculum as large in diameter as the aperture; firmly attached or even corroding a channel in the substrate. They usually occur singly, forming a flattened coil.

15.4 *Dendropoma lituella* (Mörch, 1861). Relatively small, forming a flat coil, partially embedded in abalone shells. Sculpture of scaly longitudinal cords, main dorsal cord forming a strong ridge. Operculum multispiral. Tube diameter, 4-6 mm. Occasionally on rocks but most common on abalone shells. Range: Forrester Island, Alaska, to Cedros Island, central Baja California.

Petaloconchus Lea, 1843

Operculate, tube diameter small, operculum not as wide as the tube, sculpture pitted or cancellate, an internal ridge in the early part of the tube.

15.5 *Petaloconchus montereyensis* Dall, 1919. Solitary specimens are tightly coiled, massed individuals have projecting tubes. Sculpture of diagonal wrinkles on early part of tube, surface of projecting tubes often smooth. Tube diameter, 2 mm. Common on under surfaces of rocks at low tide and in sublittoral zones. Range: Monterey, California, to San Martin Island, northern Baja California.

Family POTAMIDIDAE

The horn shells. Relatively large, brownish, operculum multispiral, anterior canal weakly developed. Inhabitants of muddy substrates, in bays and brackish water.

Cerithidea Swainson, 1840

Shell with axial and spiral sculpture, irregular varices, and a multispiral operculum. Primarily a tropical group, one species occurs in California.

16.1 *Cerithidea californica* (Haldeman, 1840). California Horn Shell. High-spired, with rounded whorls, prominent axial ribs, and weaker spiral ribbing. One or two weakly developed varices near base of shell, aperture flaring. Color brown, varices and columella lighter. Height, 25-45 mm. Abundant on mud at the high tidal level in back bays and estuaries. Range: Bolinas Bay, California, to San Ignacio Lagoon, central Baja California.

Family CERITHIIDAE

High-spired shells having an anterior siphonal notch or canal.

Bittium Gray, 1847

Small slender shells with axial and spiral sculpture, anterior canal broad, poorly defined.

16.2 *Bittium attenuatum* Carpenter, 1864. Early whorls with spiral and axial sculpture producing a cancellate pattern; in later whorls axial sculpture subdued and spiral cords flattened. Color, tan to dark brown with slight darker mottling, occasionally with white banding. Height, 8-10 mm. Common at low water and in sublittoral zones near rocks. Range: Ketchikan, Alaska, to San Geronimo Island, northern Baja California.

16.3 *Bittium interfossa* (Carpenter, 1864). A whitish shell with strong cancellate sculpture; two strong spiral cords per whorl, three rounded cords on the base, strong axial sculpture producing square pits except on base. Color usually white, some specimens with light brown bands. Height, 7-9 mm. Not uncommon in sublittoral zones under kelp. Range: Monterey Bay, California, to San Martin Island, northern Baja California.

16.4 *Bittium purpureum* (Carpenter, 1864). Shell brown, with three spiral cords per whorl on early whorls, smaller accessory cords on final whorl, base with spiral cording. Axial sculpture forms beads upon intersecting the spiral ribs. Height, 7-10 mm. Not uncommon in sublittoral gravels under kelp. Range: Monterey Bay, California, to San Martin Island, northern Baja California.

16.5 *Bittium quadrifilatum* (Carpenter, 1864). Shell brown, spiral cords four per whorl on early whorls, axial sculpture producing beading, sutures distinct, spiral cording evenly spaced on the base. Height, 9-12 mm. A shallow water species occurring chiefly in bays. Range: San Pedro, California, to Santa Maria Bay, southern Baja California.

Family CERITHIOPSIDAE

Small, slender shells with a well developed anterior notch. Some members of this family feed on sponges.

Cerithiopsis Forbes and Hanley, 1851

Sculpture consisting of strong axial and spiral ribs producing beads at intersections. There are numerous species; two of the more common are treated here.

16.6 *Cerithiopsis cosmia* Bartsch, 1907. A slender shell with nearly flat-sided whorls, three spiral cords per whorl, the axial sculpture producing a closely packed beaded effect, base with evenly spaced spiral cords. Color, variegated brown and white. Height, 7 mm. Occasionally common from low tide to sublittoral depths. Range: Monterey Bay, California, to San Bartolome Bay, central Baja California.

16.7 *Cerithiopsis carpenteri* Bartsch, 1911. Shell dark brown, whorls rounded, three spiral rows of tubercles per whorl, axial sculpture closely spaced, base with a groove and a broad cord. Height, 7-8 mm. Occasionally common on wharf pilings in bays, usually on sponges. Range: Crescent City, California, to San Geronimo Island, northern Baja California.

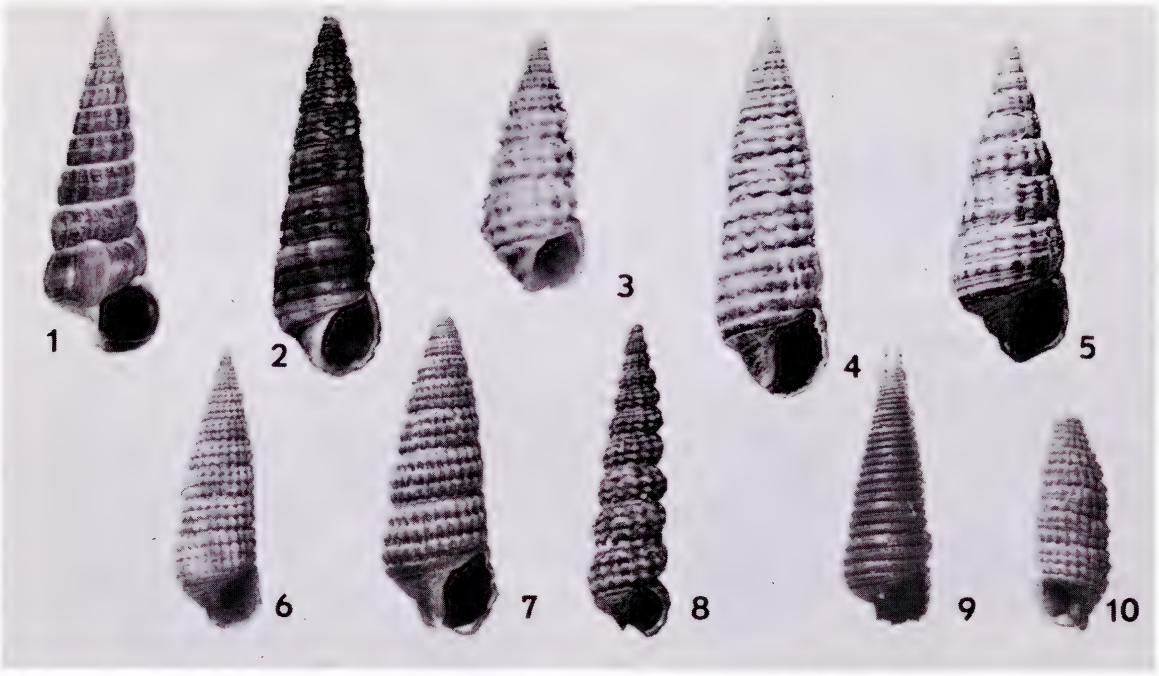

Figure 16. **1,** *Cerithidea californica*, x 1; **2,** *Bittium attenuatum*, x 4; **3,** *B. interfossa*, x 4; **4,** *B. purpureum*, x 4; **5,** *B. quadrifilatum*, x 4; **6,** *Cerithiopsis cosmia*, x 5; **7,** *C. carpenteri*, x 5; **8,** *Metaxia convexa*, x 5; **9,** *Seila montereyensis*, x 4; **10,** *Triphora pedroana*, x 5.

Metaxia Monterosato, 1884

Shell characterized by convex whorls, beaded sculpture, and concave base. A single west American species.

16.8 *Metaxia convexa* (Carpenter, 1857). Four beaded spirals per whorl, axial threads producing square cancellations. Height, 4-6 mm. Not uncommon in sublittoral gravel. Range: Monterey Bay, California, to Mazatlan, Mexico. I regard *M. diadema* Bartsch a synonym.

Seila A. Adams, 1861

Small shells with sculpture consisting of spiral ribs, anterior canal well developed.

16.9 *Seila monterevensis* Bartsch, 1907. Shell relatively large, brown, flat sided, suture indistinct. Spiral sculpture of three raised cords per whorl, minute axial threads showing in interspaces. Base slightly concave. Height, 8-12 mm, most southern Californian specimens are about 8 mm, larger ones occur in northern localities. Range: Monterey Bay, California, to Point Abreojos, central Baja California.

Family TRIPHORIDAE

Small, slender, sinistrally coiled shells, with beaded sculpture as in *Cerithiopsis*, anterior canal closed and turned upward.

Triphora Blainville, 1828

Several species are known and one is relatively common in southern California.

16.10 *Triphora pedroana* Bartsch, 1907. Shell brown, whorls flat sided, overall outline of shell convex. Spiral sculpture of two strong-beaded cords per whorl, with a third middle cord increasing in prominence until nearly equal in the final whorl. Canal closed, base of shell rounded, sculptured with spiral cording. Height, 4-6 mm. Not uncommon, at low tide and in sublittoral gravels. Range: Monterey Bay, California, to San Geronimo Island, northern Baja California.

Family EPITONIIDAE

The wentletraps are turreted, whitish shells with rounded apertures. The few species studied are parasitic upon coelenterates, particularly sea anemones. The animals produce a

purple dye, which often stains the shells. The radula is atypical of mesogastropods, consisting of many simple teeth per row.

Epitonium Röding, 1798

Axial sculpture consisting of thin ridges or varices. A number of species occur in California; all but one live offshore on sandy bottoms.

17.1 *Epitonium tinctum* (Carpenter, 1864). TINTED WENTLETRAP. A small shell with rounded whorls and about 12 thin varices, continuous from whorl to whorl. A narrow brown line just below the suture is characteristic. Height, 10-15 mm. Not uncommon near the base of small sea anemones exposed at low tide. Range: Vancouver, British Columbia, to Magdalena Bay, Baja California.

Opalia H. and A. Adams, 1853

Wentletraps lacking varices, but having rounded axial ribs.

17.2 *Opalia funiculata* Carpenter, 1857. SCULPTURED WENTLETRAP. This species has a tabulate shoulder, weak axial ribs most apparent at the shoulder, and a strong basal keel. Height, 12-20 mm. Hermit crab inhabited shells are common; living specimens are found at the bases of large green anemones in the low intertidal zone. Range: Santa Monica, California, to Panama. *Opalia insculpta* Carpenter and *O. crenimarginata* Dall are synonyms used in older literature for this species.

17.3 *Opalia montereyensis* (Dall, 1907). Shell with rounded whorls, thick projecting axial ribs, microscopic spiral lines, and a projecting basal disk. Height, 10-16 mm. Uncommon at sublittoral depths under kelp. Range: Forrester Island, Alaska, to Magdalena Bay, Baja California.

Family EULIMIDAE

Shells are small and glassy, with flat-sided whorls. The radula is lacking in this family. The few species studied are parasitic upon echinoderms.

Balcis Gray, 1847

High-spired glassy white shells, lacking a color pattern. Several species are known from sandy bottoms offshore, but only one is characteristic of rocky bottoms.

17.4 *Balcis thersites* (Carpenter, 1864). A small, solid white shell, whorls slightly inflated and spire tilted to one side. Not uncommon in gravel under kelp. Height, 4-7 mm. Range: Monterey, California, to San Geronimo Island, northern Baja California.

Family VANIKORIDAE

Umbilicate white shells, with wide apertures.

Macromphalina Cossmann, 1888

Umbilicus deep, shell rapidly inflating, with projecting nuclear whorls. Primarily tropical, one species occurs in California.

17.5 *Macromphalina californica* Dall, 1903. Fine axial and spiral sculpture imparts a roughened appearance to the surface of the shell. Body whorl rounded except for the angular rim of the umbilicus. Height, 5.5 mm. Uncommon in gravel under kelp. Range: Santa Rosa Island, California, to Point Abreojos, central Baja California.

Family HIPPONICIDAE

Limpet-shaped shells with spirally coiled nuclear whorls, prominent horseshoe-shaped muscle scar, open anteriorly; operculum lacking.

Hipponix Defrance, 1819

White shells with a fibrous periostracum. Sedentary forms, the foot of most species secretes a shelly platform on the substrate. Food consists of organic detrius obtained with a long proboscis. Two species occur in southern California.

17.6 *Hipponix antiquatus* (Linnaeus, 1767). HOOF SHELL. Shell variable in height and shape, apex near the posterior end. Sculpture of flat, concentric ridges and fine radial striae beneath a light brown periostracum. Diameter, 12-25 mm. Found in colonies on undersurfaces of rock or in crevices, from low water to sublittoral depths. Range: Neah Bay, Washington, to Panama.

17.7 *Hipponix tumens* Carpenter, 1864. RIBBED HOOF SHELL. Shell with apex down-

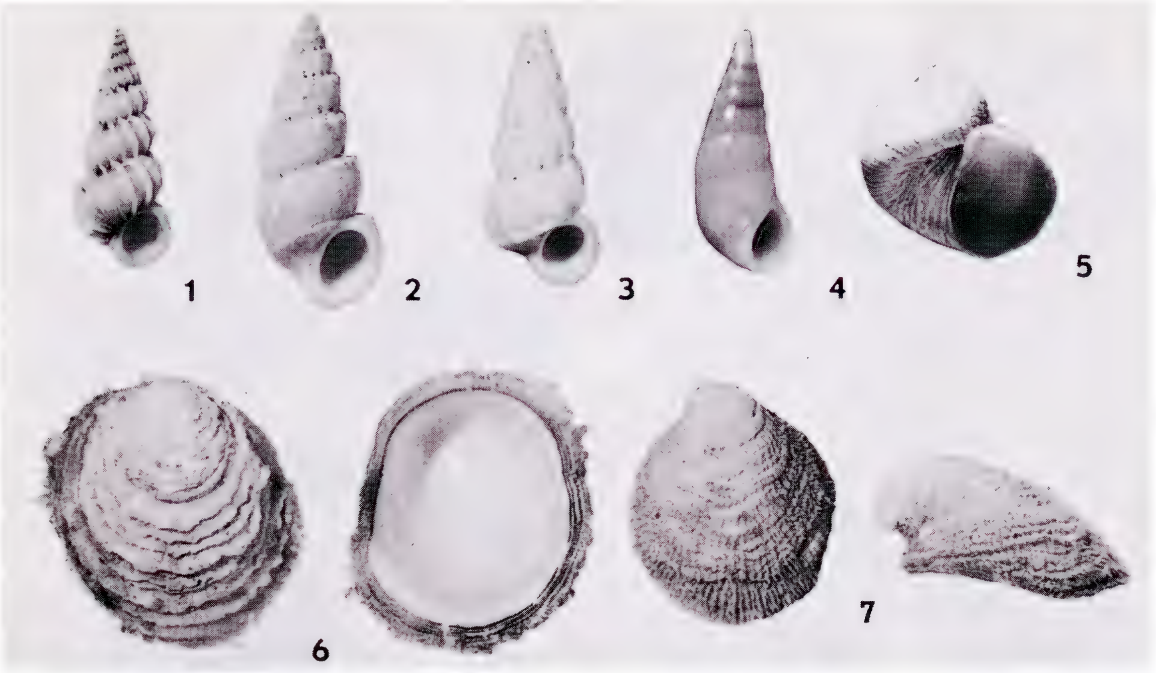

Figure 17. **1,** *Epitonium tinctum*, x 2; **2,** *Opalia funiculata*, x 1.5; **3,** *O. montereyensis*, x 3; **4,** *Balcis thersites*, x 4; **5,** *Macromphalina californica*, x 5; **6,** *Hipponix antiquatus*, x 1.5; **7,** *H. tumens*, x 2.

curved and overhanging the posterior margin. Sculpture consisting of prominent regular radial ridges, crossed by weaker concentric sculpture, bearing fine periostracal hairs. Length, 12-15 mm. Not uncommon in rock crevices at low water and in the sublittoral zone. Range: Crescent City, California, to Magdalena Bay, Baja California.

Family CALYPTRAEIDAE

Another group of limpet-shaped shells. Unlike the primitive limpets, they have an internal shelf that serves as a structural support for the soft parts. All are sedentary, adapting the form of the shell to the irregularities of the substrate. They are ciliary feeders, trapping detrital material with mucus.

Crepidula Lamarck, 1799

The slipper limpets are flattened shells with apex overhanging the posterior margin and a broad deck extending forward through about half of the shell.

18.1 *Crepidula aculeata* (Gmelin, 1791). SPINY SLIPPER SHELL. Whitish shell with lateral apex and spinose spiral ridges. The shelf is laterally notched and has a central longitudinal fold. Californian specimens are smaller (to 13 mm), and lighter in color than southern specimens, which reach 40 mm. Uncommon in the sublittoral zone. Range: Cayucos, California, to Valparaiso, Chile, also occurring in the Caribbean and Indo-Pacific provinces.

18.2 *Crepidula adunca* Sowerby, 1825. HOOKED SLIPPER SHELL. Shell brown, margin oval, apex high above and overhanging the posterior margin. Deck white, extending anteriorly on both sides, a deep cavity at the posterior end of the deck. Length, 15-25 mm. The most abundant species in northern California, it is uncommon in southern California. It occurs chiefly on gastropod shells. Range: Queen Charlotte Islands, British Columbia, to Santo Tomas, northern Baja California.

18.3 *Crepidula coei* Berry, 1950. Shell relatively high, light tan with brown mottling, periostracum thin, apex overhanging the posterior margin. Deck white, flat, slightly extending forward on the sides, deep cavity at

Figure 18. **1,** *Crepidula aculeata*, x 1.5; **2,** *C. adunca*, x 1.5; **3,** *C. coei*, x 1.5; **4,** *C. norrisiarum*, x 1.5 ; **5,** *C. onyx*, x 1; **6,** *C. perforans*, x 1.5; **7,** *Crepipatella lingulata*, x 1.5; **8,** *Crucibulum spinosum*, x 1.5.

posterior end of deck. Length, 20-30 mm. Occasionally common on gastropods such as *Polinices*. Range: Southern California to Baja California. The species has been confused with *Crepidula excavata*, a distinct, more southern species.

18.4 *Crepidula norrisiarum* Williamson, 1905. Shell relatively low, apex overhanging and close to the posterior margin; color light brown under a fine brown periostracum. Shelf white, projecting forward on the sides, differing from *C. coei* in lacking the cavity between end of deck and shell margin. Length, 20-30 mm. Common on shells, particularly *Norrisia norrisi*. Range: Cayucos, California, to southern Baja California.

18.5 *Crepidula onyx* Sowerby, 1824. Onyx Slipper Shell. Relatively large, low to arched, apex at posterior margin of shell, color brownish under a thick periostracum, interior glossy brown, deck white, with a lateral notch and medial fold. Length, 25-70 mm. Abun-

dant in bays and lagoons, common elsewhere at low tide to sublittoral depths on shells and rocks. Range: Southern California to Peru.

18.6 *Crepidula perforans* (Valenciennes, 1846). WHITE SLIPPER SHELL. A white species with a thin brown periostracum; overall shape variable, deck with lateral notch and medial fold. Three major situs forms occur: 1) normal, found on rock surfaces; 2) elongate, concave outer surface, found within the apertures of gastropod shells occupied by hermit crabs; 3) elongate, with foliated outer surface, found in empty pholad holes in rocks. Length, 15-40 mm. Range: Vancouver Island, British Columbia, to Baja California. A more northern species, *Crepidula nummaria* Gould differs in having a thick, shaggy periostracum.

Crepipatella Lesson, 1831

Similar to *Crepidula* but differing in having the deck attached to the shell interior on one side.

18.7 *Crepipatella lingulata* (Gould, 1846). HALF-SLIPPER SHELL. Shell oval to round, low to moderately elevated, color mottled brown and white, deck with raised medial fold, detached on one side. Length, 12-25 mm. Abundant on rocks at all depths. Range: Bering Sea, Alaska, to Asuncion Island, central Baja California.

Crucibulum Schumacher, 1817

Shell with a cup-shaped shelf attached at the base and usually along one side. Primarily a tropical group, one species ranges to southern California.

18.8 *Crucibulum spinosum* (Sowerby, 1824). SPINY CUP-AND-SAUCER. Shell moderately elevated, with a nearly circular base. Apex twisted, surface with concentric rows of tubular spines, internal shelf attached on one side. Color brownish white with darker rays in a radial pattern. Diameter, 20-30 mm. Abundant on clam shell rubble in shallow bays at low water. Range: San Pedro, California, to Chile.

Family NATICIDAE

The moon snails have a relatively low spire, rounded body whorl and oval aperture. They live on sand or mud bottoms and plow through the substrate with a greatly expanded foot that forms a shield over the head. Shells are somewhat glossy because the body envelops the shell. Carnivorous, they feed upon clams by drilling round holes with the radula. Eggs are deposited in a collar-shaped structure made by cementing sand grains with mucus.

Polinices Montfort, 1810

Shell with a columellar thickening or callus, operculum corneous, few whorled.

19.1 *Polinices lewisii* (Gould, 1847). LEWIS' MOON SNAIL. Shell large, heavy, with a shallow channel at the shoulder of the whorl, columellar callus extending to the side of the deep, narrow umbilicus. Height, 75-130 mm. Occasionally common at low water in bays and lagoons, also offshore on sandy bottoms. Range: Duncan Bay, British Columbia, to San Geronimo Island, northern Baja California.

19.2 *Polinices draconis* (Dall, 1903). DRAKE'S MOON SNAIL. With a thinner shell than *P. lewisii*, and not quite as large, this species has a rounded or tabulate shoulder, no columellar callus, and a broad umbilicus showing a thick periostracum. Height, 50-90 mm. An offshore species on sandy bottoms, found as shallow as 60 feet. Range: Trinidad, California, to Todos Santos Bay, northern Baja California.

19.3 *Polinices reclusianus* (Deshayes, 1839). RECLUZ'S MOON SNAIL. Shell tan colored, whorls flat sided; a heavy white callus extending from the suture covers the umbilicus except for a chink. Height, 40-70 mm. Fairly common in lagoons and shallow bays, not characteristic of offshore sand bottoms. Range: Mugu Lagoon, California, to Mazatlan, Mexico. Placed in the subgenus *Neverita* Risso, 1826, characterized by a heavy callus pad.

19.4 *Polinices altus* (Pilsbry, 1929). HIGH MOON SNAIL. Shell similar to that of *P. reclusianus* but smaller, frequently more elevated, with a brown rather than white callus tongue covering only half the umbilicus. Height, 25-40 mm. This species is found on offshore sandy bottoms in relatively shallow water, rarely in

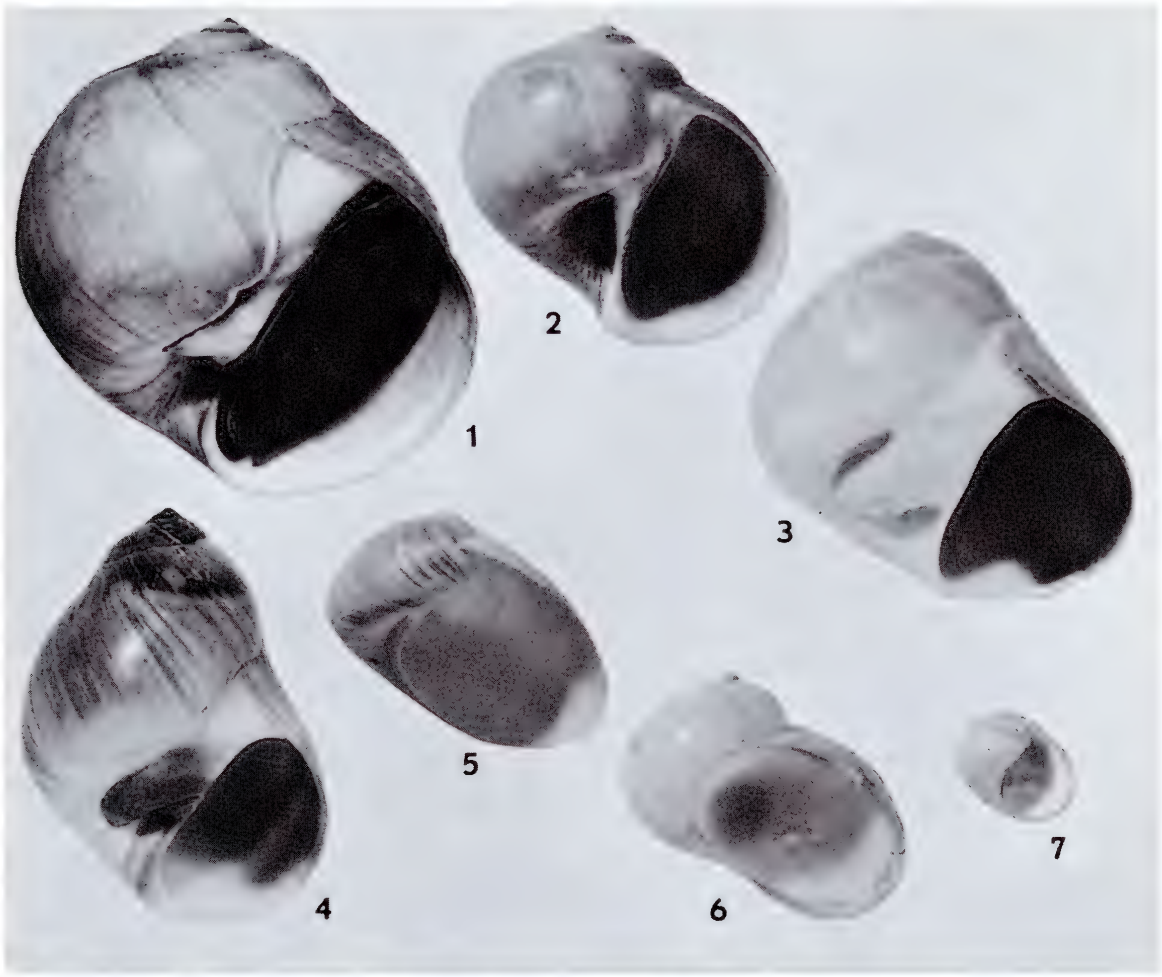

Figure 19. **1,** *Polinices lewisii*, x .7; **2,** *P. draconis*, x .7; **3,** *P. reclusianus*, x 1.5; **4,** *P. altus*, x 1.5; **5,** *Sinum scopulosum*, x 1; **6,** *Lamellaria diegoensis*, x 2; **7,** *L. sharonae*, x 2.

bays, except at entrances. Range: Monterey Bay, California, to Ensenada, northern Baja California.

Sinum Röding, 1798

Relatively thin shells with inflated body whorl and sculpture of fine spiral grooves.

19.5 *Sinum scopulosum* (Conrad, 1849). Shell with a greatly inflated body whorl, depressed spire, and sculpture of fine incised spiral lines. Color, yellowish white under a fine periostracum. Maximum diameter, 30-40 mm. Occasionally found at low water in shallow bays, also on sandy bottoms offshore. Range: Monterey Bay, California, to Todos Santos Bay, northern Baja California. *Sinum californicum* Oldroyd is a synonym.

Family LAMELLARIIDAE

Small, white-shelled forms with an internal shell or one fully enveloped by the mantle. Members of this family feed upon tunicates, the animals having color patterns that resemble the host species.

Lamellaria Montagu, 1813

Two species occur in southern California.

19.6 *Lamellaria diegoensis* Dall, 1885. San Diego Lamellaria. The internal shell is inflated, fragile, white, with impressed suture. The animal has orange and black papillae on the dorsal surface and an extended siphon and tentacles. Diameter of shell, to 20 mm. Uncommon in protected rocky areas at

low water and in sublittoral zones. Range: Monterey Bay, California, to Santo Tomas, northern Baja California.

19.7 *Lamellaria sharonae* Willett, 1939. The internal shell is relatively small and has a thin periostracum; suture not impressed. Animal reddish with dark spots. Height of shell, 7 mm. Occasionally occurring in numbers on rocks and pilings in bays. Range: Anaheim Bay, California, to the Gulf of California.

Family ERATOIDAE

Short-spired shells with elongate aperture, outer lip folded in, inner and outer lips bearing denticles. Like the Lamellarias, they feed upon tunicates.

Erato Risso, 1826

Glossy, with smooth whorls and a projecting spire. Two species occur in California.

20.1 *Erato vitellina* Hinds, 1844. APPLESEED ERATO. Shaped like an inverted pear; aperture with 5-8 denticles on columellar lip, 7-10 on outer lip. Dorsal surface of shell purplish red, white on the apertural margin. Height, 15 mm. Not uncommon, low water to sublittoral depths. Range: Bodega Bay, California, to Magdalena Bay, Baja, California.

20.2 *Erato columbella* Menke, 1847. Similar to *E. vitellina* but smaller. Outer lip with about 12 denticles, inner lip bearing traces of denticles in mature specimens. Color gray to reddish brown, apertural margin white. Height, 5-7 mm. Not uncommon at low tide in eelgrass and in gravel at sublittoral depths. Range: Monterey Bay, California, to Panama.

Trivia Broderip, 1837

Shaped like the Cypraeids, Trivias have a concealed spire and have transverse ridges extending around the shell. The following two Californian species are placed in the subgenus *Pusula* Jousseaume, 1884, characterized by a mid-dorsal furrow, with rib ends beaded on either side.

20.3 *Trivia californiana* (Gray, 1827). CALIFORNIA TRIVIA. Shell dark purple, having numerous whitish ribs extending from the dorsal furrow to the inside of the aperture, additional ribs terminating before reaching the aperture. Length, 9-11 mm. Seldom found at low tide, but not uncommon in sublittoral depths in rocky areas. Range: Crescent City, California, to Acapulco, Mexico.

20.4 *Trivia solandri* (Sowerby, 1832). SOLANDER'S TRIVIA. Larger than *T. californiana*, this is lighter in color, has a broad dorsal furrow and well spaced ribs terminating in white pustules. Length, 13-16 mm. Uncommon at low tide and in the shallow sublittoral in southern California, but fairly common to the south. Range: Palos Verdes, California, to Panama.

Family CYPRAEIDAE

Cowry shells are smooth and the polished glaze is preserved by the mantle margins of the animal, extending dorsally. The spire is concealed in the mature shell, the aperture is elongate and infolded; both lips are provided with denticles.

Cypraea Linnaeus, 1758

Primarily a tropical group with a single species of the subgenus *Zonaria* occurring in southern California.

20.5 *Cypraea spadicea* Swainson, 1823. CHESTNUT COWRY. Pale on the base, with an irregular chestnut-brown area on the dorsal surface, outlined with a broad band of darker brown. Length, 40-65 mm. Occasionally found in numbers along ledges at low tide, particularly during the winter, but fairly common throughout the year in the sublittoral zone, especially under overhung rock ledges. Range: Monterey, California, to Cedros Island, central Baja California. Seldom found north of Santa Barbara County.

Family OVULIDAE

The ovulids are similar in shape to the cowries but are more elongate and lack the denticulation on the outer and inner lips. All are parasitic upon coelenterates, chiefly gorgonians, but some species occur on corals, hydrocorals, and sea pens.

Simnia Risso, 1826

Slender, oval shells, chiefly parasitic on gorgonians. There are several deep water species in California, but only one occurs in the shallow sublittoral zone. *Neosimnia* is a synonym.

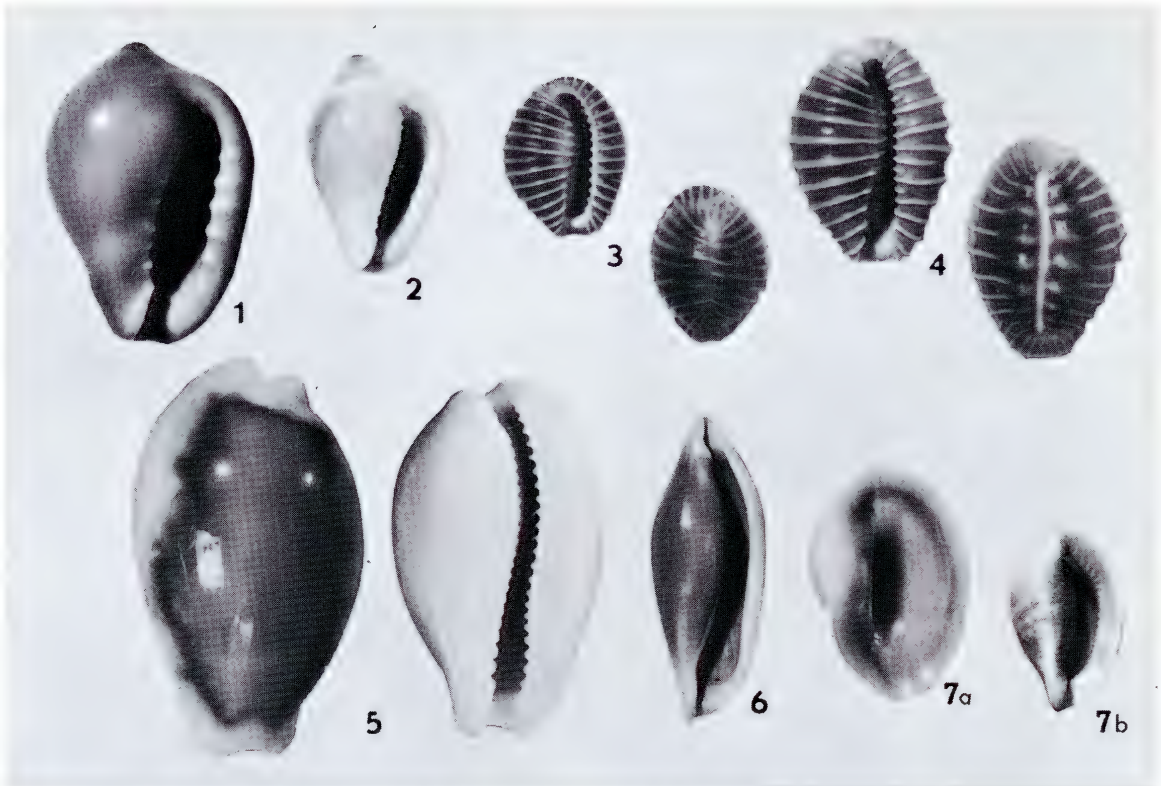

Figure 20. **1,** *Erato vitellina,* x 3; **2,** *E. columbella,* x 5; **3,** *Trivia californiana,* x 2; **4,** *T. solandri,* x 2; **5,** *Cypraea spadicea,* x 1; **6,** *Simnia vidleri,* x 2; **7,** *Pedicularia californica,* x 3.

20.6 *Simnia vidleri* (Sowerby, 1881). VIDLER'S SIMNIA. Shell rose colored with orange tips and a light colored outer lip. Sculpture of fine incised spiral lines at the anterior and posterior ends; columella with a white ridge. Height, 15-22 mm. Not uncommon on red gorgonians at depths of 30-100 feet, particularly at the offshore islands. Range: Monterey Bay, California, to San Martin Island, northern Baja California.

Pedicularia Swainson, 1840

Shell with a broadly inflated body whorl and a concealed spire. Parasitic on hydrocorals, a single species occurs in the eastern Pacific.

20.7 *Pedicularia californica* Newcomb, 1864. CALIFORNIA PEDICULARIA. Shell purplish pink with broadly inflated outer lip, turned-out inner lip, and fine spiral sculpture. Height, 7-11 mm. Found on the purplish hydrocoral *Allopora,* which lives in open water with strong currents. Range: Farallon Islands to Catalina Island, California. Particularly common at Farnsworth Bank, off Catalina Island, 70-130 feet. The species is polymorphic, a less common form is smaller and has a denticulate ridge within the outer lip. This may represent the male of the species, and bears the name *ovuliformis* Berry, 1946.

Family BURSIDAE

The bursids have two varices per whorl, a well developed anterior notch or siphonal canal, and a deep posterior notch or anal canal.

Bursa Röding, 1798

Primarily a tropical genus, a single species occurs in California.

21.1 *Bursa californica* (Hinds, 1843). CALIFORNIA FROG SHELL. A relatively large solid shell, with spiral sculpture of irregular cords and a series of blunt peripheral nodes. Color, light tan with a white aperture. Height,

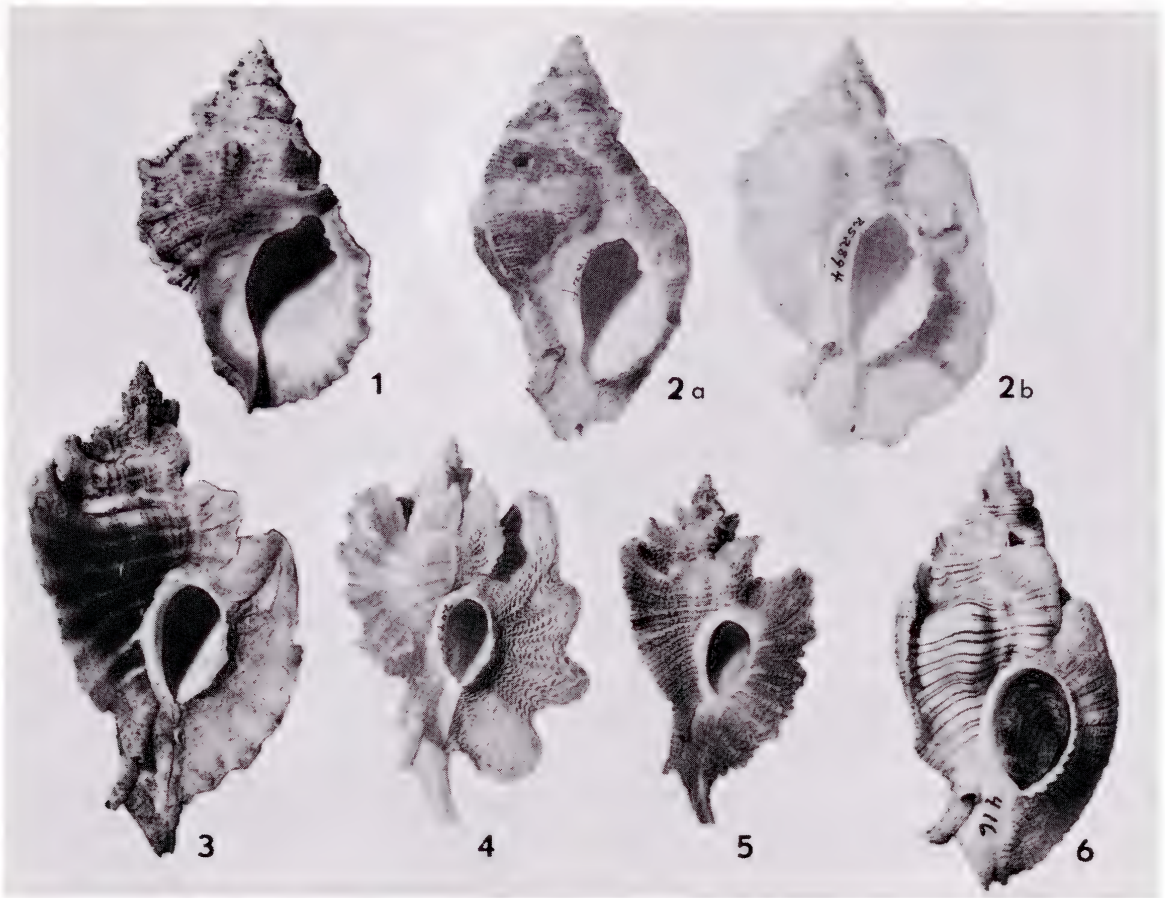

Figure 21. **1,** *Bursa californica*, x .5; **2,** *Ceratostoma nuttalli*, x 1; **3,** *Pteropurpura trialata*, x .7; **4,** *P. macroptera*, x 1; **5,** *P. vokesae*, x 1; **6,** *P. festiva*, x 1.

55-130 mm. Small specimens occur half buried in gravel pockets between rocks; larger specimens taken by dredging on sandy bottoms. Range: Monterey Bay, California, to the Gulf of California.

Order NEOGASTROPODA

The neogastropods or "new gastropods" generally have long siphons for water intake, a structure that permits burrowing in some groups. The shells often have long siphonal canals serving to protect the siphons. Most are carnivorous, although some are scavengers upon dead matter. The osphradium, a sensory organ, is well developed, and may serve in finding food. The radula usually has three teeth per row, except in the Conacea, where it is toxoglossate—reduced to single spear-like teeth.

Family MURICIDAE

The murex or rock shells are of medium to large size, have regularly spaced varices that are often spiny, and a well developed anterior or siphonal canal. There are numerous genera and species throughout the world. All are carnivorous, some drill irregular holes in the shells of their molluscan prey.

Ceratostoma Herrmannsen, 1846

Moderately large shells, characterized by having three varices per whorl, a closed siphonal canal, and a short spine projecting from the edge of the outer lip near the base. Only one species is common in southern California.

21.2 *Ceratostoma nuttalli* (Conrad, 1837). NUTTALL'S HORNMOUTH. Shell with three sharp edged varices, a prominent nodu-

lar axial rib between varices, and denticles within the outer lip. Color whitish, brown, or brown and white banded. Varices may be flaring or poorly developed. Height, 30-55 mm. Range: Point Conception, California, to Santa Maria Bay, southern Baja California.

Pteropurpura Jousseaume, 1880

The three-winged muricids are relatively large high-spired shells with three flaring varices, faces of varices with fine fimbriations, canal closed along its length. Listed in older works as *Pterynotus*.

21.3 *Pteropurpura trialata* (Sowerby, 1841). THREE-WINGED MUREX. Shell relatively large, with one low axial nob between varices, body whorl with slightly raised, broad spiral ribs terminating in digitations on the varices. Shell whitish, usually dark colored between the spiral ribs, occasionally solid white. Height, 55-80 mm. Chiefly intertidal, not uncommon along ledges at low water, particularly on breakwaters and at bay entrances. Range: Palos Verdes, California, to Cedros Island, central Baja California.

21.4 *Pteropurpura macroptera* (Deshayes, 1839). Slightly smaller than *P. trialata*, the body whorl is rounded between varices. Color, tan with slightly darker broad spiral ribs, pure white, or brown and white banded. Height, 50-70 mm. An offshore form, uncommon on rocky bottoms below 60 feet. Range: Monterey Bay, California, to Todos Santos Bay, northern Baja California. Synonyms are *Murex carpenteri* Dall, *petri* Dall, *tremperi* Dall, and *alba* Berry.

21.5 *Pteropurpura vokesae* Emerson, 1964. Smaller than the two preceding forms, this species has an axial ridge between varices and is characterized by the extreme scaliness of the fine spiral ridges, particularly on the surface of the varix. Height, 45-60 mm. Like *P. macroptera*, it is uncommon on rocky bottoms offshore. Range: Santa Rosa Island, California, to San Bartolome Bay, Baja California. A synonym, *Murex rhyssus* Dall, is preoccupied.

21.6 *Pteropurpura festiva* (Hinds, 1844). FESTIVE MUREX. Shell moderately large, high spired, with backward rolled varices, fine brown spiral lines, and a single strong axial node between the finely foliated varices. Height, 40-50 mm. Large specimens are common in muddy and rocky areas within bays. Smaller specimens occur on the exposed coast, at low tide and in sublittoral depths on rocky bottoms. Range: Santa Barbara, California, to Magdalena Bay, Baja California. Placed in the subgenus *Shaskyus* Burch and Campbell, 1964, characterized by the backward rolled varices.

Ocenebra Gray, 1847

Relatively small shells, with scaly spiral sculpture, axial ribbing, closed or narrow canal, and denticles within the outer lip. Numerous species occur in the eastern Pacific. Listed as *Tritonalia* in some older works.

22.1 *Ocenebra atropurpurea* Carpenter, 1865. Spire with two strong spiral ribs per whorl, about seven on the body whorl; axial sculpture producing raised intersections and deep, squarish pits. Color, brown, occasionally with a yellow or orange peripheral rib. Height, 10-14 mm. Not uncommon at sublittoral depths on rocky bottoms. Range: Sitka, Alaska, to San Martin Island, northern Baja California. I regard *Ocenebra clathrata* Dall a synonym.

22.2 *Ocenebra barbarensis* (Gabb, 1865). Shell high spired, with a long, closed canal. Spiral cording subdued on the shoulder, periphery with a projecting row of spines, strong spiral cording on the rest of the body whorl. Color, tan. Height, 15-20 mm. Not common, at depths below 100 feet on rocky bottoms. Range: Monterey to Catalina Island, California.

22.3 *Ocenebra beta* (Dall, 1919). Similar to *O. barbarensis*, but with a shorter canal. Spiral cording on the shoulder subdued. Upturned, blunt spines at the shoulder arise from axial ribs extending the length of the shell. Color, tan to dark brown, occasionally with darker banding. Not common on rocky bottoms under kelp. Populations vary in detail of sculpturing from one locality to another. Height, 15-21 mm. Range: Monterey to Imperial Beach, California. I regard *Ocenebra keenae* Bormann a synonym.

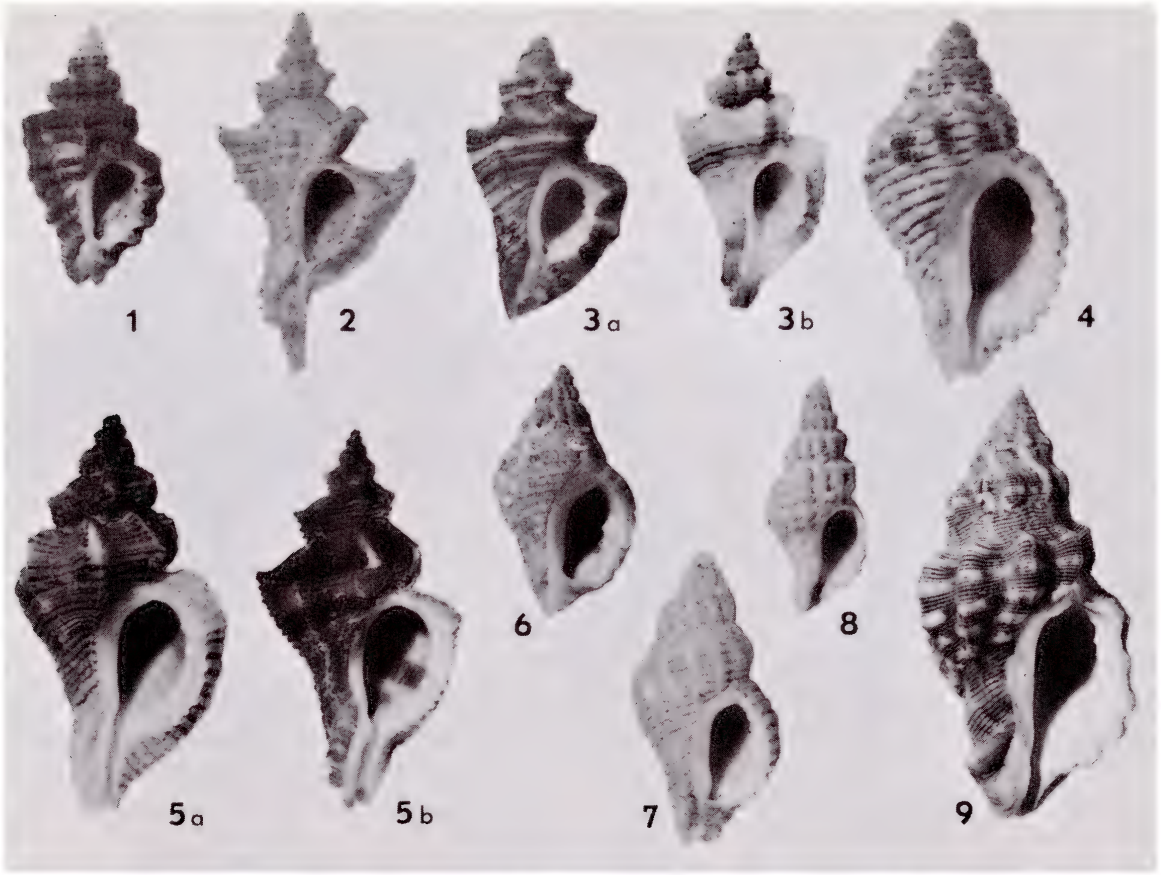

Figure 22. **1,** *Ocenebra atropurpurea*, x 2; **2,** *O. barbarensis*, x 2; **3,** *O. beta*, x 2; **4,** *O. circumtexta*, x 2; **5,** *O. foveolata*, x 2; **6,** *O. gracillima*, x 2; **7,** *O. lurida*, x 2; **8,** *O. minor*, x 3; **9,** *O. poulsoni*, x 1.

22.4 *Ocenebra circumtexta* Stearns, 1871. Circled Rock Shell. Shell with strong, regular spiral cords, narrow interspaces, and rounded, low, axial ribs. Aperture strongly denticulate within. The usual color is whitish with two interrupted brown bands per whorl. Height, 15-20 mm. Characteristically an intertidal species, common in rocky crevices at midtide. Range: Monterey, California, to Scammons Lagoon, central Baja California.

22.5 *Ocenebra foveolata* (Hinds, 1844). Relatively large, with regular spiral ribbing, well-spaced axial ribs, 6-7 per whorl. Axial ribs rounded, blunt, or angulate at periphery. Outer lip denticulate. Color brownish, often with two darker spiral bands. Height, 25-38 mm. A highly variable species. Local populations may be fairly uniform, but they may differ widely from area to area. Range: Monterey Bay, California, to Magdalena Bay, Baja California. I regard the following as synonyms: *O. squamulifera* Carpenter; *O. fusconotata* Dall; *O. epiphanea* Dall.

22.6 *Ocenebra gracillima* Stearns, 1871. A relatively small species having fine spiral sculpture and weak axial sculpture. Lip thickened, denticulate within, canal always closed. Color yellowish brown, usually with two whitish bands, spiral ribs faintly dotted with brown. Height, 9-14 mm. Fairly common on the undersurfaces of rocks at low tide. Range: Monterey, California, to Todos Santos Bay, northern Baja California.

22.7 *Ocenebra lurida* (Middendorff, 1848). Lurid Rock Shell. Shell of medium size, with regular spiral ribs and about nine axial ribs, shoulder rounded. Color, yellow brown, occasionally banded, rib surface usually darker. The shell proportions are variable. Height, 15-25 mm. Chiefly a northern species,

common at low tide north of Point Conception, taken only occasionally at sublittoral depths in southern California. Range: Sitka, Alaska, to Santo Tomas, northern Baja California. Slender specimens have been given the varietal name *munda* Carpenter, which I regard as a synonym.

22.8 *Ocenebra minor* (Dall, 1919). MINOR ROCK SHELL. A small species, with three spiral cords per whorl on spire; axial ribs strong, producing square cancellations. Whorls shouldered, sides straight, base of shell constricted, canal open. Color whitish, usually with a single brown band on the base. Height, 8-10 mm. Not uncommon in the sublittoral zone, particularly under kelp. Range: Monterey, California, to San Geronimo Island, northern Baja California.

22.9 *Ocenebra poulsoni* (Carpenter, 1864). POULSON'S ROCK SHELL. A relatively large species with spiral sculpture of fine, incised brown lines and several broad white spiral ribs. Axial sculpture consists of strong ribs below the concave shoulder. Aperture white, outer lip denticulate. Height, 30-50 mm. Large specimens are common on rocks and wharf pilings at bay entrances and within bays; specimens at adjacent localities on the exposed coast are less abundant and are smaller. Range: Santa Barbara, California, to Magdalena Bay, Baja California.

Maxwellia Baily, 1950

Solid, short-spired shells with six or seven varices that are folded back and joined to varices of earlier whorls. A deep pit occurs behind the varices at the suture. Aperture nearly round, canal closed.

23.1 *Maxwellia gemma* (Sowerby, 1879). GEM MUREX. Shell as above, whitish, with raised black spiral ribbing, no space between varices. Height, 25-35 mm. Fairly common at times in rocky areas, particularly on breakwaters and bay entrances and in the sublittoral zone. Range: Santa Barbara, California, to Asuncion Island, central Baja California.

23.2 *Maxwellia santarosana* (Dall, 1905). SANTA ROSA MUREX. Shell dingy white, surface of varices brown, scaly, with smooth whitish areas between varices. Height, 25-40 mm. Sublittoral, common on the sides of boulders below a depth of 40 feet. Range: Point Estero, California, to San Bartolome Bay, central Baja California.

Forreria Jousseaume, 1880

Forreria is the largest Californian muricid. There is a single living species.

23.3 *Forreria belcheri* (Hinds, 1844). BELCHER'S MUREX. A large, heavy shell with 9-10 spinose varices, lower portion of the body whorl constricted, siphonal fasciole showing tips of siphonal canals from earlier growth stages. Height, 90-140 mm. Found offshore on sandy bottoms in relatively shallow water of 60-100 feet and within bays and lagoons, where it is only occasionally exposed at low tide. Range: Mugu Lagoon, California, to Scammons Lagoon, central Baja California.

Family CORALLIOPHILIDAE

Related to the Muricidae but lack the radula. Most members of this family are parasitic upon corals.

Latiaxis Swainson, 1840

White-shelled forms with scaly spiral ribbing; shoulder keeled and bearing projecting spines.

23.4 *Latiaxis oldroydi* (I. Oldroyd, 1929). OLDROYD'S LATIAXIS. Shell with a spinose peripheral keel, about 10 upturned spines per whorl, with scaly spiral cording throughout, body whorl with four strongly developed spiral cords. Small specimens have long upturned spines, which are poorly developed on larger specimens. Height, 20-47 mm. Uncommon below 80 feet at Catalina Island. Range: Point Conception, California, to Cedros Island, central Baja California.

Family THAISIDAE

Stout shells of medium size, with short spires and wide apertures. Most species occur in the mid and upper intertidal zones and are predatory upon mussels and barnacles. Lacking varices, they have knobby or spinose sculpture. The operculum is distinguished from that of the muricids in having an internally thickened ridge along the outer edge.

Figure 23. **1,** *Maxwellia gemma,* x 1.5; **2,** *M. santarosana,* x 1.5; **3,** *Forreria belcheri,* x .7; **4,** *Latiaxis oldroydi,* x 1.

Acanthina Fischer de Waldheim, 1807

Characterized by the projecting spine on the lower part of the outer lip.

24.1 *Acanthina spirata* (Blainville, 1832). ANGULAR UNICORN. A solid shell always with a prominent keel at the shoulder. Spiral sculpture consists of light colored often scaly ribs, interspaces with interrupted dark lines. Highly variable in size and sculptural details. Large specimens occur on breakwaters at the entrances of bays. Height, 20-37 mm. Range: Tomales Bay, California, to Camalu, northern Baja California.

24.2 *Acanthina punctulata* (Sowerby, 1825). SPOTTED UNICORN. Similar to *A. spirata* but having a rounded shoulder with slight indication of a peripheral carina. Spiral sculpture not as strong as in *spirata,* frequently worn smooth. Color pattern spotted, showing more frequent vertical interruptions than in *spirata.* Height, 20-30 mm. Common in the upper intertidal zone. Range: Monterey, California, to Santo Tomas, northern Baja California. Highly variable, some populations resemble *A. spirata.* The two species occur together in Monterey harbor and are easily separable there; *spirata* occupying the lower, and *punctulata* the upper intertidal zone.

24.3 *Acanthina paucilirata* (Stearns, 1871). CHECKERED UNICORN. A shouldered species, similar to *A. spirata,* but broader, with about four raised, white spiral ribs on the final whorl. The black area between ribs interrupted with irregular white, axial banding. Height, 15-25 mm. Fairly common in the upper intertidal zone. Range: San Pedro, California, to Cedros Island, central Baja California, but not common north of San Diego.

Thais Röding, 1798

Shell similar to *Acanthina* but lacking the spine on the outer lip. Characteristic of upper intertidal zones. A single species of the subgenus *Nucella* occurs in southern California.

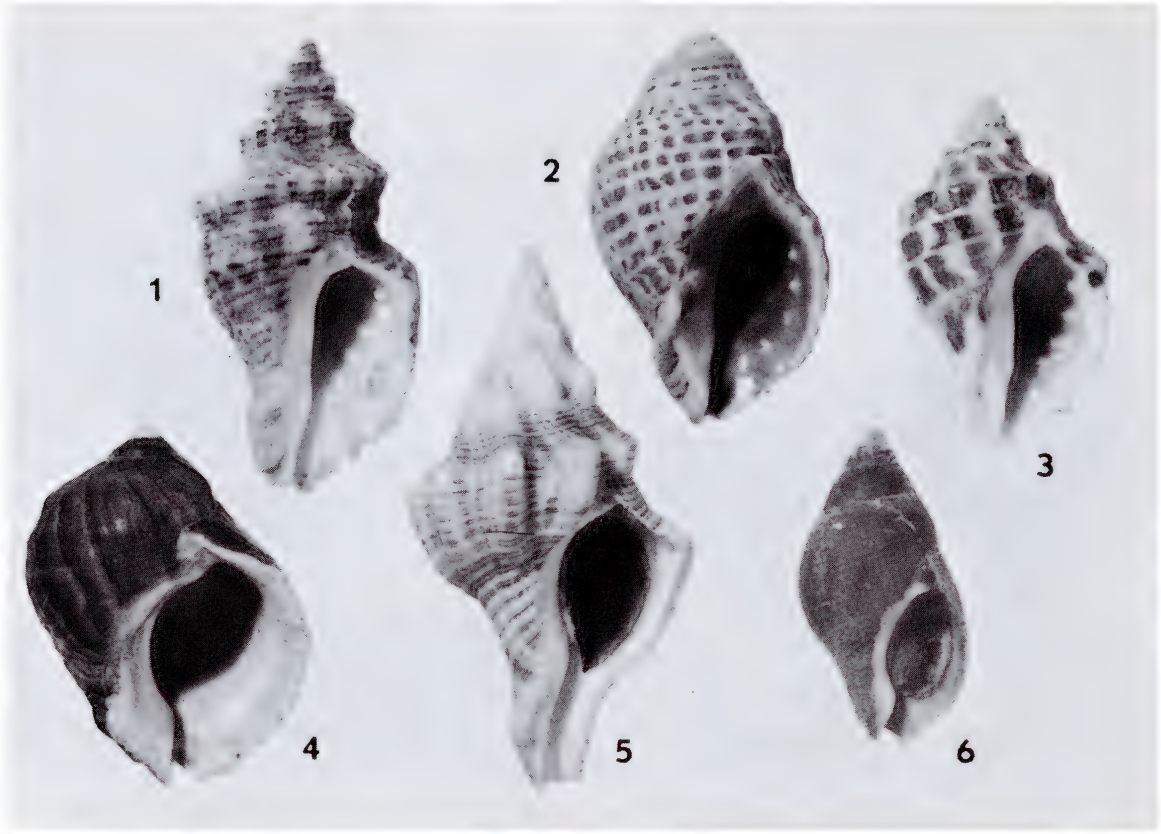

Figure 24. **1,** *Acanthina spirata,* x 1.5; **2,** *A. punctulata,* x 1.5; **3,** *A. paucilirata,* x 3; **4,** *Thais emarginata,* x 1.5; **5,** *Kelletia kelletii,* x 1; **6,** *Macron lividus,* x 2.

24.4 *Thais emarginata* (Deshayes, 1839). EMARGINATE DOGWINKLE. Shell stout, spire short, aperture more than half the length of the shell, columella concavely arched, flattened. Spiral sculpture of irregular roughened ribs; color brownish, with light and dark spiral banding. Height, 20-35 mm. Found in rock crevices near mussel beds. Typically a northern species, not common south of Point Conception. Range: Bering Sea to northern Baja California.

Family BUCCINIDAE

Stout shells with an elevated spire and well developed open siphonal canal, columella lacking folds. Operculum with an apical nucleus.

Kelletia Fischer, 1884

Represented by a single species in the eastern Pacific.

24.5 *Kelletia kelletii* (Forbes, 1852). KELLET'S WHELK. Large and heavy, whitish, with rounded nodes at the periphery and fine spiral striae. Siphonal fasciole broad. Height, 90-170 mm. Common on rocky and gravel bottoms below ten feet; seldom found living at low water. Range: Point Conception, California, to Asuncion Island, central Baja California.

Macron H. and A. Adams, 1853

Shell with a closely adherent, fibrous brown periostracum, axial sculpture lacking, spiral sculpture of incised lines. One species occurs in southern California.

24.6 *Macron lividus* (A. Adams, 1855). LIVID MACRON. Shell relatively small, whorls rounded. Base of shell with spiral incisions, columella concavely arched and bearing a small parietal ridge near the suture. Height, 20-25 mm. Common in rocky areas at low

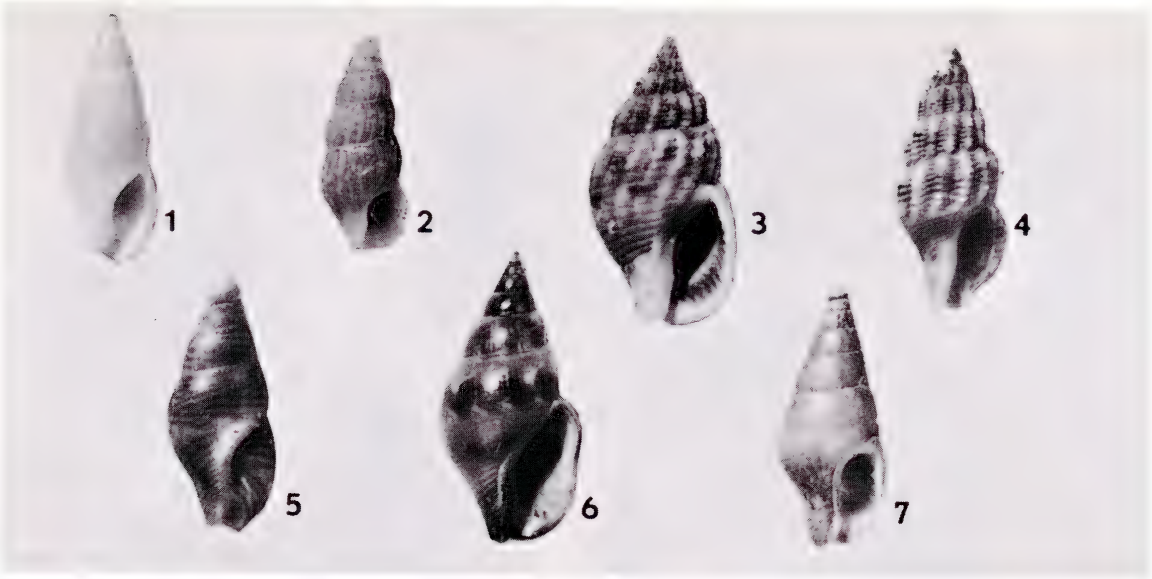

Figure 25. **1,** *Aesopus chrysalloides,* x 3; **2,** *A. subturrita,* x 7; **3,** *Amphissa versicolor,* x 2; **4,** *Nassarina penicillata,* x 6; **5,** *Mitrella aurantiaca,* x 8; **6,** *M. carinata,* x 4; **7,** *M. tuberosa,* x 5.

tide. Range: Orange County, California, to San Bartolome Bay, central Baja California.

Family COLUMBELLIDAE

Small-shelled species with a broadly open anterior notch. There are numerous genera in tropical and temperate waters having diverse patterns of sculpture and color. Unlike most neogastropods, the columbellids feed on algal films or detritus.

Aesopus Gould, 1860

Shell relatively small, high spired, with short aperture.

25.1 *Aesopus chrysalloides* (Carpenter, 1864). A small white shell characterized by fine spiral grooves and denticles within the outer lip of mature specimens. Height, 7-10 mm. Not common, dredged offshore to depths of 100 feet. Range: Santa Monica to San Diego, California.

25.2 *Aesopus subturrita* (Carpenter, 1864). A minute high-spired species with convex whorls and axial sculpture of rounded ribs. Color brownish with white dots or pattern of spiral streaking. Height, 3-5 mm. Not uncommon in sublittoral gravel. Range: San Pedro, California, to Cape San Lucas, Baja California.

Amphissa H. and A. Adams, 1853

Characterized by fine spiral and axial sculpture. One species occurs in the intertidal zone, several others in deeper water.

25.3 *Amphissa versicolor* Dall, 1871. VARIEGATED AMPHISSA. A sturdy shell with fine spiral ribbing and wavy axial ribs, columellar area with a glossy shield, inner lip with spiral striations. Color, mottled gray, brown, or white, with some darker spiral banding. Height, 13-17 mm. Common at low water and in the sublittoral. Range: Fort Bragg, California, to San Martin Island, northern Baja California.

Nassarina Dall, 1889

Small shells with deep sutures and strong axial and spiral ribbing.

25.4 *Nassarina penicillata* (Carpenter, 1864). PENCILLED DOVE SHELL. A small species with prominent, rounded axial ribs and fine spiral ribs, base with spiral ribs alone. Suture deeply impressed, base constricted. Color, pale brown with spiral and diagonal brown lines. Height, 5 mm. Fairly common from screenings at low tide and the sublittoral. Range: San Simeon, California, to Asuncion Island, central Baja California.

Mitrella Risso, 1826

Small shells lacking axial sculpture, spiral sculpture present at the base of the canal, outer lip usually denticulate in mature shells.

25.5 *Mitrella aurantiaca* (Dall, 1871). A relatively small, slender form with a smooth shell except for the spirally striate canal. Characterized by thin brown lines in a chevron pattern on a yellow brown base color. Height, 3-4 mm. Not uncommon in sublittoral gravel. Range: Fort Bragg, California, to Magdalena Bay, Baja California.

25.6 *Mitrella carinata* (Hinds, 1844). CARINATE DOVE SHELL. A small, glossy shell with a fine periostracum. The shoulder of the final whorl smooth to strongly carinate; canal with incised spiral lines. Color highly variable, usually yellowish brown, canal and outer lip dark brown, the carina usually lighter in color, some specimens variegated with white and darker brown. Abundant near eelgrass and algae from low water to sublittoral depths. Height, 8-11 mm. Range: Forrester Island, Alaska, to southern Baja California.

25.7 *Mitrella tuberosa* (Carpenter, 1864). Shell more slender than that of *M. carinata,* sides nearly flat. The periostracum of living specimens forms axial ridges. Color, tan, some specimens showing fine white mottling and some darker colored. Height, 6-8 mm. Chiefly sublittoral, not uncommon in gravel under kelp. Range: Forrester Island, Alaska, to southern Baja California.

Family NASSARIIDAE

Nassariid mud snails are scavengers and move rapidly over sand and mudflats in search of food. A large, world-wide group with most species placed in the following broadly defined genus.

Nassarius Duméril, 1805

Characterized by a deep groove or fossa at the base of the shell. The columella is concave and the siphonal notch is short. Sculpture spiral and axial, often producing cancellations. The operculum has a jagged edge on the side adjacent to the outer lip.

26.1 *Nassarius fossatus* (Gould, 1849). CHANNELED NASSA. Shell large, early whorls finely cancellate. Axial sculpture in the mature shell produces spaced diagonal ridges. Columellar callus broad, lip crenulate, spirally ridged within. Color, dark orange. Height, 35-45 mm. Fairly common in bays and lagoons, also on sandy bottoms offshore to depths of 60 feet. Range: Vancouver Island, British Columbia, to San Ignacio Lagoon, central Baja California.

26.2 *Nassarius mendicus* (Gould, 1849). LEAN NASSA. A relatively high-spired species with fine spiral sculpture and 7-12 axial ribs. Under the periostracum the color is brown with light and dark spiral banding. Most southern California specimens have few ribs, but the number of ribs is variable; some populations have up to 12 ribs per whorl. Height, 15-20 mm. Fairly common in bays, along the open coast at low tide, and in sublittoral depths. Range: Kodiak Island, Alaska, to Asuncion Island, central Baja California. Synonym, *N. cooperi* Forbes, based on many-ribbed specimens.

26.3 *Nassarius perpinguis* (Hinds, 1844). FAT NASSA. Shell light brown with fine cancellate sculpture, sometimes with spiral bands of darker brown. Height, 18-22 mm. Occasionally exposed at low tide in lagoons, common on bay bottoms and offshore in shallow water. Range: Point Reyes, California, to Cedros Island, central Baja California.

26.4 *Nassarius tegula* (Reeve, 1853). MUD NASSA. Shell low-spired, sculpture of incised spiral lines and nodes at the shoulder; outer lip thickened, inner lip with a broad white parietal callus extending well above the aperture. Color, brownish gray under an adherent periostracum, usually with a purplish peripheral band. Height, 15-19 mm. Common at times on sandy mudflats in bays and lagoons at low tide. Range: Santa Barbara, California, to San Ignacio Lagoon, central Baja California.

Family FUSINIDAE

Spindle shells have high spires and long canals, fine spiral ribbing and prominent axial ribs. The columella is smooth, not plicate, operculum with an apical nucleus.

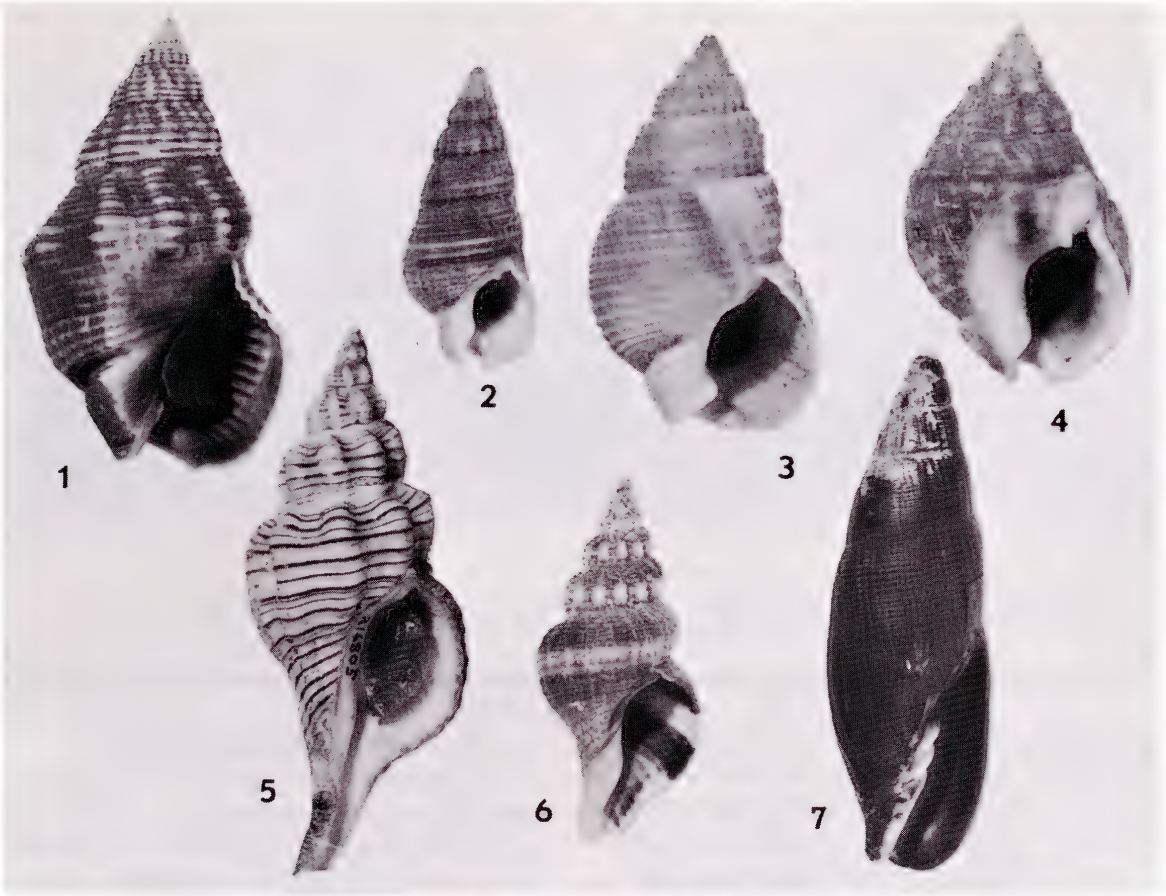

Figure 26. **1,** *Nassarius fossatus*, x 1; **2,** *N. mendicus*, x 2; **3,** *N. perpinguis*, x 2; **4,** *N. tegula*, x 2; **5,** *Fusinus kobelti*, x 1; **6,** *F. luteopictus*, x 1.5; **7,** *Mitra idae*, x 1.

Fusinus Rafinesque, 1815

Two species occur in shallow water, others live offshore.

26.5 *Fusinus kobelti* (Dall, 1877). KOBELT'S SPINDLE. Shell whitish under a light brown periostracum; spiral ribs narrow, slightly raised and dark colored, axial ribs prominent, well spaced, about 10 per whorl. Height, 40-60 mm. Uncommon on rocky bottoms under kelp, occasionally found at Catalina Island. Range: Santa Barbara, California, to Cedros Island, central Baja California.

26.6 *Fusinus luteopictus* (Dall, 1871). PAINTED SPINDLE. Shell relatively small, with fine spiral ribs, axial ribs strong on early whorls, poorly developed on final whorl. Color dark brown with a broad whitish band on the periphery, tip of canal light colored. Height, 20-26 mm. Relatively common at low tide and on rocky bottoms under kelp. Range: Monterey, California, to San Geronimo Island, northern Baja California.

Family MITRIDAE

Elongate shells, usually with high spires and short siphonal canals, characterized by heavy plaits on the columella, the uppermost plait the largest.

Mitra Röding, 1798

Primarily a tropical group. One species is common in southern California.

26.7 *Mitra idae* Melvill, 1893. IDA'S MITER. Shell heavy, with three strong columellar folds, brown but covered with a thick, closely adherent black periostracum. Sculpture of fine spiral and axial striations, producing fine pitting. Variable in proportion; broad

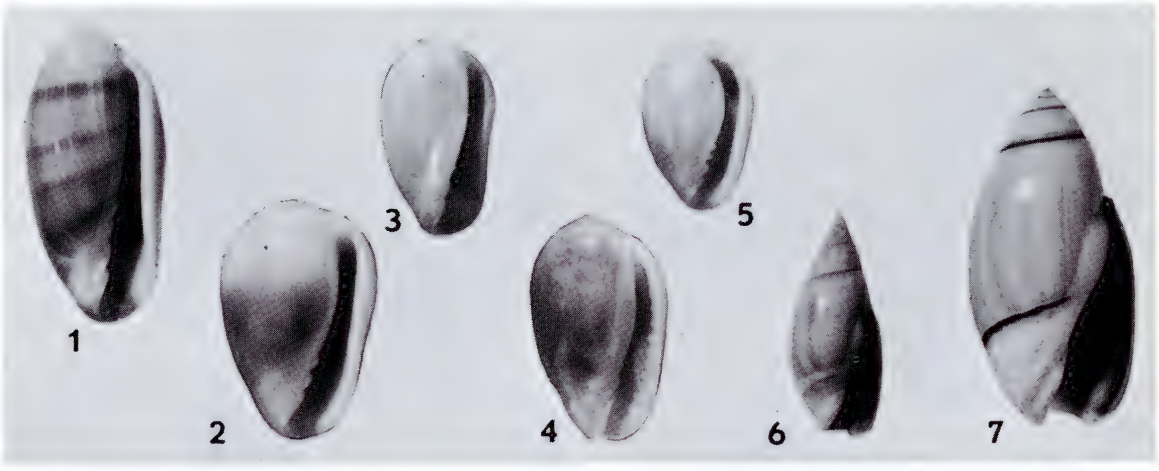

Figure 27. **1,** *Volvarina taeniolata*, x 5; **2,** *Cystiscus jewettii*, x 7; **3,** *C. politulus*, x 9; **4,** *Granula subtrigona*, x 9; **5,** *Granulina margaritula*, x 7; **6,** *Olivella baetica*, x 1.5; **7,** *O. biplicata*, x 1.5.

and slender forms occur. Height, 20-60 mm. Occasionally found at low tide, but chiefly sublittoral in rocky areas under kelp, often common. Range: Crescent City, California, to Cedros Island, central Baja California. Synonyms include *M. catalinae* Dall, *M. diegensis* Dall, and *M. montereyi* Berry.

Family MARGINELLIDAE

Small glossy shells with low spire, thickened outer lip and columellar folds. The mantle of active animals envelops the shell, keeping it polished. Primarily a tropical group, although a few species occur in cool water areas.

Volvarina Hinds, 1844

Small, elongate. A single species occurs in the eastern Pacific.

27.1 *Volvarina taeniolata* Mörch, 1860. California Marginella. A small cylindrical species with four columellar folds and a smooth thickened lip. Color, yellow orange with spiral banding of white. Height, 7-10 mm. Common on the undersides of rocks at low tide, also at sublittoral depths. Range: Point Conception, California, to Ecuador. Listed in older works at *Hyalina californica* Tomlin.

Cystiscus Stimpson, 1865

Minute white shells with low spire, smooth outer lip, and shallow anterior notch.

27.2 *Cystiscus jewettii* (Carpenter, 1857). Shell small, outer lip thickened, columella with four folds. Height, 3-5.5 mm. Not uncommon in rocky areas, low tide to sublittoral zones. Range: Monterey, California, to Point Abreojos, central Baja California.

27.3 *Cystiscus politulus* (Dall, 1919). Shell minute, white, with three main columellar folds, one or two smaller ones posteriorly, outer lip smooth, aperture widest at base. Height, 2.7-3 mm, smaller than *C. jewettii*. Common in gravel at low tide and in the sublittoral zone. Range: Santa Barbara, California, to Cape San Lucas, Baja California. An unavailable name, *C. regularis*, is listed in older works.

Granula Jousseaume, 1875

Small white shells. Aperture narrow, outer lip denticulate, anterior notch deep. This genus has recently been listed as *Kogomea* Habe, but *Granula* has priority.

27.4 *Granula subtrigona* (Carpenter, 1864). Shell minute, whitish, anterior notch deep, lip denticulate within, aperture widest

anteriorly, columella with four folds. Height, 3-3.5 mm. Not uncommon, intertidal and sublittoral to 200 feet. Range: Monterey, California, to Cape San Lucas and La Paz, Baja California.

Granulina Jousseaume, 1888

Small white shells with aperture extending slightly over the spire, outer lip denticulate within. A single species is represented in the eastern Pacific. This genus has been known as *Cypraeolina*, but *Granulina* has priority.

27.5 *Granulina margaritula* (Carpenter, 1857). Shell as above, height, 2-3 mm. Not uncommon in gravel, low tide and sublittoral. Range: Afognak Island, Alaska, to Panama. *Cypraeolina pyriformis* Carpenter is a synonym.

Family OLIVIDAE

Olive shells are highly polished and cylindrical with an elongate aperture. Columella with folds or ridges, outer lip smooth. Primarily a tropical group, all species live on soft bottoms rather than rock. The front portion of the foot is plow shaped, enabling the animal to burrow just beneath the surface of the sand.

Olivella Swainson, 1840

Mostly slender, high-spired shells, possessing a small operculum. There are a large number of tropical west American species, but only two occur in southern California. One species, *Olivella pycna* Berry, occurs in northern California.

27.6 *Olivella baetica* Carpenter, 1864. Beatic Olivella. Shell slender, columellar callus weakly developed, base of columella with two small folds. Color, grayish brown, often with faint brown maculations below the suture. Height, 10-17 mm. Common at times, exposed in lagoons at low tide, common offshore on sandy bottoms in shallow water. Range: Kodiak Island, Alaska, to Cape San Lucas, Baja California.

27.7 *Olivella biplicata* (Sowerby, 1825). Purple Olivella. Shell relatively large, robust, columellar callus extending from the aperture to the fasciole, 2-3 small folds at the base. Color light gray, occasionally all white or brownish gray, fasciole area white with a violet suffusion, usually offset with a dark line. Height, 20-27 mm. Common at lagoon entrances and protected sandy areas of the open coast at low tide, abundant in shallow water offshore along exposed sandy beaches. Range: Vancouver Island, British Columbia, to Magdalena Bay, Baja California.

Family CANCELLARIIDAE

Characterized by cancellate sculpture, short anterior canal, columellar folds, and no operculum.

Cancellaria Lamarck, 1799

Heavy shells with tight coiling and strong columellar folds.

28.1 *Cancellaria cooperi* Gabb, 1865. Cooper's Nutmeg. Large, high-spired shells with slightly concave shoulder and two columellar folds, outer lip with plicae. Color, yellow brown, with low, thin spiral cords of darker brown. Broad axial ribs on the body whorl terminate at the shoulder in projecting nobs. Height, 40-90 mm. Uncommon on offshore sandy bottoms, occasionally found by divers but more often dredged. Range: Monterey, California, to San Benito Island, central Baja California.

Family CONIDAE

Brightly colored shells having a low spire and an aperture extending nearly the full length of the body whorl. Columella and outer lip smooth, operculum small. Conids have toxoglossate radula consisting of barblike teeth that are detached and held singly by the proboscis. A poison gland produces a venom that paralyzes the prey.

Conus Linnaeus, 1758

Most species live in tropical waters, and only a single rather drab species occurs in southern California.

28.2 *Conus californicus* Hinds, 1844. California Cone. Shell grayish brown with fine spiral markings of brown under a thick periostracum. The spire is flat sided and the shoulder rounded, aperture broader at base. Height, 25-40 mm. Common on rocky and sandy bottoms from low water to 100 feet, the largest specimens found offshore. Range: Farallon

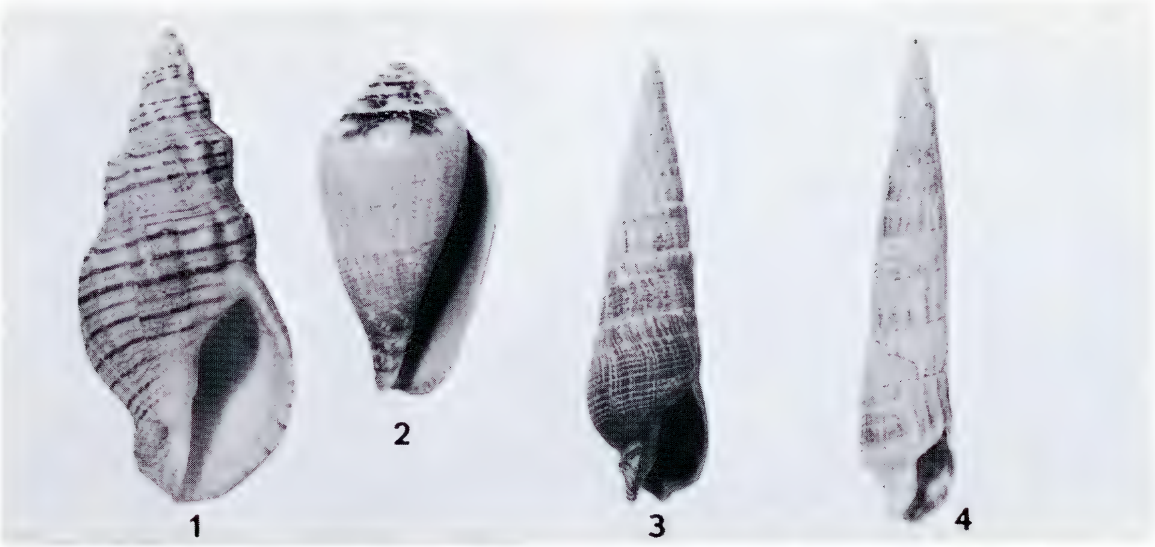

Figure 28. **1,** *Cancellaria cooperi,* x 1; **2,** *Conus californicus,* x 1.5; **3,** *Terebra danai,* x 1.5; **4,** *T. pedroana,* x 1.5.

Islands, California, to Magdalena Bay, Baja California.

Family TEREBRIDAE

Augur shells are elongate, slender, and many whorled, with a short anterior notch and a siphonal fasciole. They live on sand or mud bottoms. Like the Conidae they are carnivorous, having barbed teeth and a poison gland.

Terebra Brugière, 1789

Shell with one or two small folds on the columella and some axial sculpture. Two species occur in southern California.

28.3 *Terebra danai* Berry, 1958. DANA AUGUR. Shell with fine axial sculpture in the early whorls, final whorl smooth except for a narrow band of nodes just below the suture. Spiral sculpture of fine incised lines. Color, brownish under a thin periostracum, nodular band whitish. Height, 25-30 mm. Not uncommon on offshore sandy bottoms, 60 feet and deeper. Range: Redondo Beach, California, to southern Baja California. Synonyms include *T. simplex* Carpenter and *T. philippiana* Dall, both preoccupied.

28.4 *Terebra pedroana* Dall, 1908. SAN PEDRO AUGUR. Shell with spiral incisions and axial ribs that are strong on the final whorl, subsutural band offset but not bearing strong nodes. More elongate than *T. danai.* Height, 30-45 mm. Found with *T. danai,* on offshore sandy bottoms. Range: San Pedro, California, to southern Baja California.

Family TURRIDAE

Turrids comprise a very large family with numerous genera and species. They are generally high spired or fusiform, with many sculptural patterns, but all have in common an anal notch or slit on the posterior margin of the lip. This notch is reflected in the growth lines made by the lip. The radula is toxoglossate.

Megasurcula Casey, 1904

Large tapered shells with a shallow, rounded notch, aperture extending about half the length of the shell.

29.1 *Megasurcula carpenteriana* (Gabb, 1865). CARPENTER'S TURRID. Shell yellowish with narrow brown bands. Spiral sculpture of fine striae. Subsutural area slightly concave, periphery rounded or shouldered, some specimens with strong peripheral nodes. Height, 50-95 mm. Fairly common on offshore sandy bottoms, 50-300 feet. Range: Bodega Bay, California, to Cedros Island, central Baja California. Synonyms include *M. tryoniana* Gabb

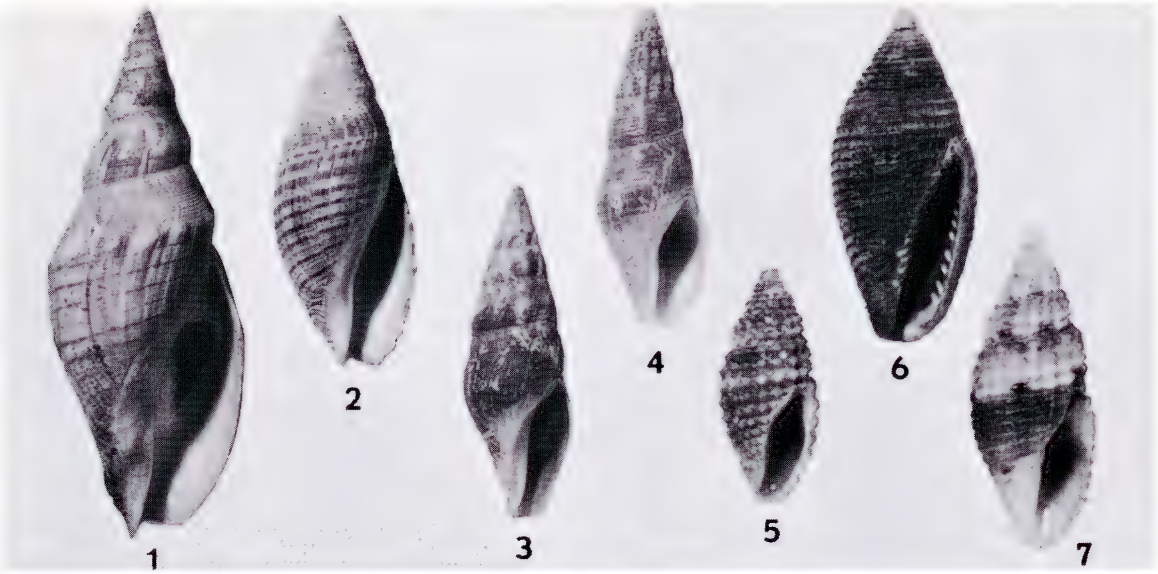

Figure 29. **1,** *Megasurcula carpenteriana*, x .7; **2,** *M. stearnsiana*, x .7; **3,** *Pseudomelatoma penicillata*, x 1.5; **4,** *P. grippi*, x 1.5; **5,** *Mitromorpha aspera*, x 6; **6,** *M. carpenteri*, x 6; **7,** *M. gracilior*, x 6.

and *M. tremperiana* Dall, based on nodular specimens.

29.2 *Megasurcula stearnsiana* (Raymond, 1906). STEARNS' TURRID. Similar to *M. carpenteriana* but somewhat smaller, subsutural area only slightly concave, whorls rounded, never nodular. Ground color yellowish, with dense brown lines in the subsutural area and regularly spaced broad bands over the body whorl. Found on offshore sandy bottoms with *M. carpenteriana*. Height, 30-60 mm. Range: Monterey, California, to Todos Santos Bay, northern Baja California. Synonym, *M. remondii*, of authors.

Pseudomelatoma Dall, 1918

High-spired shells with strong axial sculpture, a closely adherent periostracum, a subsutural constriction, shallow anal notch, and unthickened outer lip.

29.3 *Pseudomelatoma penicillata* (Carpenter, 1864). Sculpture of 10 slanting axial ribs per whorl, subsutural area with nodes. Color, grayish, sometimes with spots or linear markings under a closely adherent yellowish periostracum. Height, 25-40 mm. Fairly common among rocks at low tide and in the shallow sublittoral. Range: Santa Barbara, California, to Magdalena Bay, Baja California. I regard *P. moesta* Carpenter a synonym.

29.4 *Pseudomelatoma grippi* (Dall, 1919). Shell with subsutural groove, early whorls with about 13 strong axial ribs, lacking on the final whorl, fine spiral ribbing present at all growth stages. Color, yellowish brown. Height, 17-27 mm. Uncommon on rocky bottoms under kelp. Range: San Pedro, California, to San Martin Island, northern Baja California.

Mitromorpha Carpenter, 1865

Small shells with strong spiral sculpture, aperture approximately half the length of the shell. The anal notch is not apparent, but the genus has a turrid radular structure.

29.5 *Mitromorpha aspera* (Carpenter, 1864). A small brown shell with axial and spiral ribs equally spaced and strongly beaded at intersections, producing squarish cancellations. Height, 4-5 mm. Not uncommon in gravel at low tide and in sublittoral zones. Range: Monterey, California, to Coronado Islands, northern Baja California.

29.6 *Mitromorpha carpenteri* Glibert, 1954. Shell dark brown with narrow, raised spiral cords, outer lip finely denticulate. Height, 5-8 mm. Occasionally common under

rocks at low tide and in the sublittoral zone. Range: Monterey, California, to Mazatlan, Mexico. A synonym, *M. filosa* Carpenter, is preoccupied.

29.7 *Mitromorpha gracilior* (Tryon, 1884). A small brown shell often mottled with white. Spiral sculpture strong, interrupted by axial furrows. Columella with two weak plications. Height, 5-6.5 mm. Not common in the sublittoral zone under kelp in southern California, more common to the north at low tide. Range: Monterey, California, to San Geronimo Island, northern Baja California.

Crassispira Swainson, 1840

Dark-colored shells having axial and spiral sculpture. Subsutural area smooth, lip thickened, anal notch deep, anterior canal short, deeply notched. Although many species occur in tropical waters to the south, only one is common in southern California.

30.1 *Crassispira semiinflata* (Grant and Gale, 1931). Shell large, dark brown to black, axial sculpture of about 14 low, slanted ribs, interrupted in the subsutural channel, base with fine spiral lines. The area between the axial ribs often fades to brown or orange. Height, 40-45 mm. Not uncommon on sand, gravel, or rocky bottoms under kelp, 50-200 feet. Range: Redondo Beach, California, to Turtle Bay, central Baja California. Previously listed as *Burchia redondoensis* (T. Burch), which I regard a synonym.

Ophiodermella Bartsch, 1944

High-spired, with elongate anterior canal, fine axial and spiral ribs, the axial ribs following successive positions of the deeply notched sinus, outer lip thin.

30.2 *Ophiodermella ophioderma* (Dall, 1908). A relatively large species with weak axial and spiral sculpture, light brown with darker growth lines. Height, 30-38 mm. Occasionally found exposed on sandbars in bays, common offshore on sandy bottoms, 50-200 feet. Range: Santa Barbara, California, to Magdalena Bay, Baja California.

Mangelia Risso, 1826

Small elongate shells with strong, well spaced axial ribs that are continuous from whorl to whorl. This genus frequently has been used in the past for many small turrids of diverse sculpture. Only one *Mangelia* occurs in California.

30.3 *Mangelia hexagona* Gabb, 1865. Shell elongate, with six strong axial ribs continuous from whorl to whorl, fine spiral striae throughout. Color, white with a dark peripheral band. Height, 8-11 mm. Not uncommon in gravel under kelp, 50-200 feet. Range: Monterey, California, to Coronado Islands, northern Baja California.

Clathromangelia Monterosato, 1884

Shell with strong spiral sculpture, producing cancellations. Anal notch a slight sinuation.

30.4 *Clathromangelia interfossa* (Carpenter, 1864). A slender elevated species with well rounded whorls, axial and spiral sculpture producing rectangular cancellations. Height, 8 mm. Uncommon at low tide and sublittoral depths in rocky areas. Range: Vancouver Island, British Columbia, to San Martin Island, northern Baja California. I regard *Mangelia interlirata* Stearns a synonym.

30.5 *Clathromangelia fuscoligata* (Dall, 1871). Shell robust, sculpture producing strong square cancellations, color whitish with brown spiral banding. Height, 8 mm. Not uncommon in gravel under kelp. Range: Monterey to San Diego, California.

Tenaturris Woodring, 1938

Shell shouldered, axial ribs sinuous, not continuous from whorl to whorl, lip thickened, anal notch deep.

30.6 *Tenaturris janira* (Dall, 1919). Shell whitish with dark mottling on the shoulder, sculpture of 9-11 sinuous, rounded axial ribs and pronounced spiral striae. Height, 8-11 mm. Not uncommon at low tide in rocky areas. Range: San Pedro, California, to Todos Santos Bay, northern Baja California.

Clathurella Carpenter, 1857

Small, shouldered shells with strong axial and spiral ribbing, anal canal deeply notched, lip thickened, denticulate within.

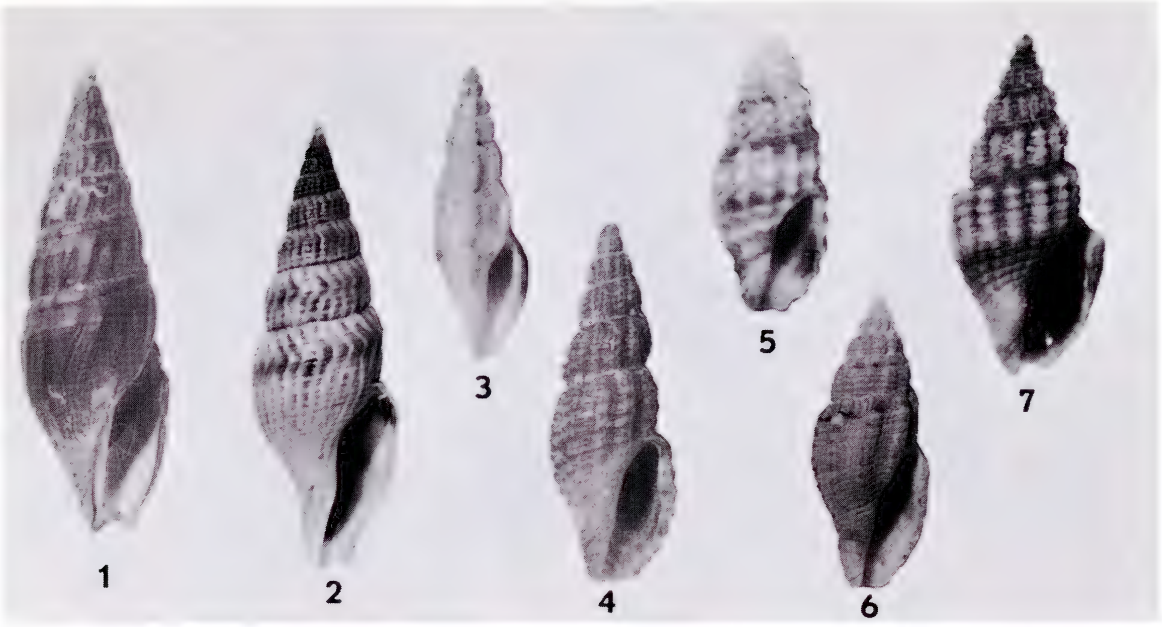

Figure 30. **1,** *Crassispira semiinflata*, x 1; **2,** *Ophiodermella ophioderma*, x 1.5; **3,** *Mangelia hexagona*, x 4; **4,** *Clathromangelia interfossa*, x 5; **5,** *C. fuscoligata*, x 5; **6,** *Tenaturris janira*, x 4; **7,** *Clathurella canfieldi*, x 5.

30.7 *Clathurella canfieldi* (Dall, 1871). Shell with about 15 strong axial ribs per whorl, crossed by spiral ribs. Color whitish, base and shoulder brown. Height, 7-9 mm. Not uncommon at low tide, especially near eelgrass. Range: Crescent City, California, to Santo Tomas, northern Baja California.

Subclass OPISTHOBRANCHIATA

Opisthobranchs have undergone detorsion, a reversal of the original process of torsion. The anterior position of the gills is lost; the gills are lateral, posterior or missing. Another name for this subclass, Euthyneura, meaning "straight nerves," refers to the straightening of the nerve cord resulting from detorsion. Reduction in size or complete loss of the shell occurs in some groups.

Order TECTIBRANCHIATA

Shelled opisthobranchs are included in this group, which means "covered gills."

Suborder CEPHALASPIDEA

Animals with a broad "headshield," upon which the eyes are centrally placed between the tentacles.

Family ACTEONIDAE

Shell with elevated spire, fine spiral sculpture, and columella with a small fold.

Acteon Montfort, 1810

Spiral striae pitted. One species occurs in shallow water.

31.1 *Acteon punctocaelatus* (Carpenter, 1864). BARREL SHELL. A white shell with two broad spiral gray bands under a fine periostracum, a thin inflated lip, and a single columellar fold. Sculpture consists of pitted, incised spiral lines. Height, 10-15 mm. Common at times on sandy bottoms in bays, at low tide and in shallow sublittoral zones. Range: Ketchikan, Alaska, to Magdalena Bay, Baja California.

Family BULLIDAE

Bubble shells are thin and inflated, with sunken spire and no columellar folds.

Bulla Linnaeus, 1758

One species occurs in California.

31.2 *Bulla gouldiana* Pilsbry, 1893. CALIFORNIA BUBBLE. A large gray brown shell, with brown maculations bordered by white

Figure 31. **1,** *Acteon punctocaelatus,* x 2; **2,** *Bulla gouldiana,* x 1; **3,** *Haminoea virescens,* x 1.5; **4,** *H. vesicula,* x 1.5; **5,** *Acteocina culcitella,* x 2; **6,** *A. inculta,* x 5; **7,** *A. harpa,* x 5.

on the side away from the lip. Columella white, thickened. Height, 30-55 mm. Common in bays and lagoons at low tide, occasionally found in protected areas along more exposed coast. Range: Santa Barbara, California, to the Gulf of California.

Family ATYIDAE

Fragile shells, with sunken spire, no columellar folds.

Haminoea Turton and Kingston, 1830

Two species occur in California.

31.3 *Haminoea virescens* (Sowerby, 1833). GREEN PAPER BUBBLE. Pale green under a closely adherent periostracum, apex of the shell tapered. Height, 12-18 mm. Occasionally common in rocky areas at low tide on the open coast, as well as in bays and lagoons. Range: Puget Sound, Washington, to southern Baja California.

31.4 *Haminoea vesicula* (Gould, 1855). GOULD'S PAPER BUBBLE. Shell fragile, white to pale green under a thin periostracum, apex relatively broad. Height, 20-24 mm. Restricted to bays, seasonally abundant on mud flats at low tide. Range: Ketchikan, Alaska, to Magdalena Bay, Baja California.

Family ACTEOCINIDAE

Shell cylindrical, aperture elongate.

Acteocina Gray, 1847

Shell with elevated spire and projecting apex, columella with strong or weakly developed fold.

31.5 *Acteocina culcitella* (Gould, 1853). Shell whitish, with a brown periostracum showing numerous dark spiral lines corresponding to spiral striae of the shell. Spire relatively high, suture channeled, columellar fold prominent. Height, 8-22 mm, smaller sizes most frequent. Occasionally common on sand and mudflats in bays, also on soft bottoms offshore. Range: Kodiak Island, Alaska, to San Ignacio Lagoon, central Baja California.

31.6 *Acteocina inculta* (Gould, 1855). A minute species with a rounded shoulder, weakly impressed suture and moderately strong columellar fold. Height, 3.5-4.5 mm. Often common on mud flats in bays and lagoons, also offshore. Range: Morro Bay, California, to the Gulf of California.

31.7 *Acteocina harpa* (Dall, 1871). A small white shell with a strongly carinate shoulder and axial striations on the upper half

of the whorl, columellar fold weak. Height, 3.5-5.5 mm. Common in gravel, low tide to sublittoral. Range: Queen Charlotte Islands, British Columbia, to San Geronimo Island, northern Baja California. Listed in older works as *Retusa*.

Family PYRAMIDELLIDAE

Small shells with rounded aperture, columellar plicae, and oval operculum. The nuclear whorls exhibit varying degrees of heterostrophic coiling, appearing sinistral and immersed or resting at right angles to the successive later whorls. Radula absent but the proboscis is adapted for suctorial feeding. A number of species are known to be externally parasitic upon invertebrates.

Iselica Dall, 1918

Small broad shells with wide umbilicus and a weak columellar fold. One species is common in southern California.

32.1 *Iselica fenestrata* (Carpenter, 1864). A small species characterized by strong spiral ribbing and thin, raised axial lamellae, producing a cancellate pattern. The shell is whitish under a brown periostracum. Height, 6-10 mm. Abundant in beds of *Mytilus edulis* on floats and pilings in bays, also common on gravel bottoms under kelp. Range: Puget Sound, Washington, to southern Baja California.

Odostomia Fleming, 1813

Minute white-shelled species with various patterns of sculpture. All have a prominent columellar fold. Species are numerous but only six common ones found on gravel at intertidal and sublittoral depths are included here. These species are assigned to several different subgenera based on sculptural patterns.

32.2 *Odostomia aepynota* Dall and Bartsch, 1909. With two strong spiral carinae per whorl, the uppermost beaded, and two spiral carinae on base. Height, 1.9 mm. Range: Palos Verdes Peninsula, California, to Cape San Lucas, Baja California.

32.3 *Odostomia eucosmia* Dall and Bartsch, 1909. Shell elevated, sculpture of three strong spiral cords per whorl, and weak axial threads not crossing spiral cords. Height, 2.5 mm. Range: Palos Verdes, California, to Point Abreojos, central Baja California.

32.4 *Odostomia helga* Dall and Bartsch, 1909. Early whorls with axial and spiral sculpture, axial sculpture lost on final whorl, which has only incised spiral lines. Height, 4.2 mm. Range: Redondo Beach, California, to San Geronimo Island, northern Baja California.

32.5 *Odostomia navisa* Dall and Bartsch, 1909. Sculpture consisting of two strong spiral ribs per whorl, with equally strong axial ribs producing beaded cancellations. Height, 2.7 mm. Range: Monterey, California, to Scammons Lagoon, central Baja California.

32.6 *Odostomia nota* Dall and Bartsch, 1909. A relatively large form with rounded whorls and microscopic spiral sculpture. Height, 7.5 mm. Common near eelgrass roots. Range: Santa Rosa Island to San Diego, California.

32.7 *Odostomia turricula* Dall and Bartsch, 1903. Shell strongly tabulate, with spiral rows of punctations. Height, 4 mm. Range: Monterey, California, to Point Abreojos, central Baja California.

32.8 *Odostomia virginalis* Dall and Bartsch, 1903. A high-spired species with axial and spiral sculpture forming weak cancellations. Height, 3 mm. Range: Redondo Beach, California, to Point Abreojos, central Baja California.

Peristichia Dall, 1889

Lacks a true columellar fold, but a heavy basal cord is continuous with the columella. A single species occurs in California.

32.9 *Peristichia pedroana* (Dall and Bartsch, 1909). Shell relatively large, dark brown. Three strong spiral cords per whorl, axial cords of equal strength, producing beaded intersections. Irregular varices may be present. Height, 6-7 mm. Not uncommon in gravel from low tide and sublittoral depths. Range: San Pedro, California, to Scammons Lagoon, central Baja California. Easily confused with *Bittium*, but differs in having a heterostrophic nuclear whorl.

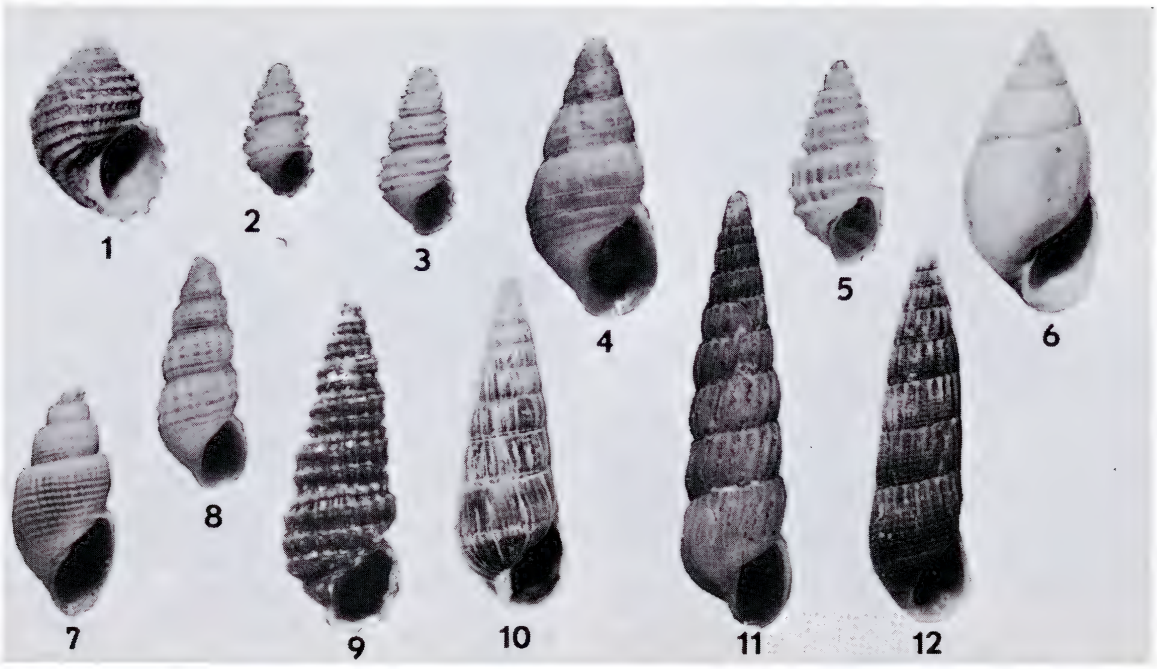

Figure 32. **1,** *Iselica fenestrata*, x 3; **2,** *Odostomia aepynota*, x 10; **3,** *O. eucosmia*, x 10; **4,** *O. helga*, x 10; **5,** *O. navisa*, x 10; **6,** *O. nota*, x 4; **7,** *O. turricula*, x 10; **8,** *O. virginalis*, x 10; **9,** *Peristichia pedroana*, x 6; **10,** *Pyramidella adamsi*, x 2; **11,** *Turbonilla kelseyi*, x 10; **12,** *T. tenuicula*, x 7.

Pyramidella Lamarck, 1799

Relatively large high-spired, flat-sided shells with deep sutural channel, columella with one to three strong folds.

32.10 *Pyramidella adamsi* Carpenter, 1864. ADAMS' PYRAM. Shell with a thick brown periostracum, an incised spiral groove at the periphery, and three columellar folds, the posterior the strongest. Height, 16-19 mm. Common at times on sand and mudflats of bays and lagoons at low tide. Range: San Pedro, California, to the Gulf of California.

Turbonilla Risso, 1826

Slender shells, of many whorls, with various combinations of axial and spiral sculpture, columellar fold weak, nuclear whorls heterostrophic. Many species occur, but only two of the common ones are included here. Common in gravel at most localities.

32.11 *Turbonilla kelseyi* Dall and Bartsch, 1909. A slender white shell with oblique axial ribs terminating at the base of the shell, spiral sculpture lacking. Height, 4.7 mm. Range: Santa Barbara, California, to San Ignacio Lagoon, central Baja California.

32.12 *Turbonilla tenuicula* (Gould, 1853). A brownish species with strong axial ribbing, poorly developed on the base, fine spiral striae on whorls and base. Height, 5-8 mm. Range: Monterey, California, to Point Abreojos, central Baja California.

Family UMBRACULIDAE

A limpet group with a cap-shaped shell. The soft parts are much larger than the shell in the tropical genus *Umbraculum*.

Tylodina Rafinesque, 1814

Shell with apex lateral to center, animal not larger than the shell.

33.1 *Tylodina fungina* Gabb, 1865. Shell thin, yellow, with a brown periostracum extending over the margin of shell. Sculpture irregular, of undulating radial ribs, interior glossy, muscle scar horseshoe shaped, opening at side of shell. The mantle and foot are bright yellow, matching the yellow or orange

Figure 33. **1,** *Tylodina fungina,* x 1; **2,** *Melampus olivaceus,* x 3; **3,** *Pedipes unisulcatus,* x 4; **4,** *Phytia myosotis,* x 4; **5,** *Williamia peltoides,* x 3; **6,** *Trimusculus reticulatus,* x 2.

sponges, upon which it feeds. Diameter, 15-30 mm. Uncommon at low tide and in sublittoral zones. Range: Morro Bay, California, to Banderas Bay, Jalisco, Mexico.

Order NUDIBRANCHIA

The brightly colored nudibranchs or sea slugs lack shells and are therefore omitted here.

Subclass PULMONATA

Pulmonates have undergone detorsion and in addition have lost the gill, being replaced by a vascularized mantle cavity, serving as a lung.

Order BASOMMATOPHORA

Eyes at the bases of the tentacles. Most marine and fresh water pulmonates are in this group. Most landsnails are in the order Stylommatophora, with eyes at the tips of the tentacles.

Family ELLOBIIDAE

Sturdy low-spired forms, with strong columellar folds, living at the high water line and slightly above it.

Melampus Montfort, 1810

Aperture elongate, outer lip having strong ribbing within. There are several tropical species but only one in southern California.

33.2 *Melampus olivaceus* Carpenter, 1857. SALT MARSH SNAIL. Low spired, with rounded shoulder, elongate aperture, a low fold at the base and a raised white fold toward the middle of the columella. Mature shells have raised white ridges within the outer lip. Color, brownish with white bands under a thick periostracum. Height, 10-14 mm. Abundant in lagoons and back bays at the drift line of the highest tides, found under debris. Range: Mugu Lagoon, California, to Mazatlan, Mexico, and the Gulf of California.

Pedipes Férussac, 1821

Low spired, with inflated whorls and spiral sculpture, three plicae on the inner lip, and a blunt denticle within the outer lip.

33.3 *Pedipes unisulcatus* Cooper, 1866. Early whorls are spirally striate but the last whorl of mature specimens is smooth. Inner

lip with three projecting plicae, the uppermost the strongest, a callosity within the outer lip. Height, 7 mm. Common in the splash zone under sloping rocky rubble along exposed areas of coast, in the same habitat as *Fartulum orcutti* and *Truncatella californica.* Range: Palos Verdes Peninsula, California, to the Gulf of California.

Phytia Gray, 1821

Shell small, elongate, spire elevated, a strong fold at base of columella, inner lip with one or two strong folds.

33.4 *Phytia myosotis* (Draparnaud, 1801). Shell small, brown. Basal and columellar folds well developed, a third fold poorly developed in some specimens. Height, 5-7 mm. Abundant at the high tide line in salt marshes in the same habitat as *Melampus olivaceus* and *Assiminea californica.* Range: Puget Sound, Washington, to Anaheim Bay, California. Thought to be introduced from Europe, the name applied to the west coast form, *P. setifer* Cooper, is a synonym.

Family SIPHONARIIDAE

Shell cap-shaped, muscle scar horseshoe shaped, opening to the right side at the siphonal groove.

Williamia Monterosato, 1884

Small thin conical shells, typically sublittoral in habit, in contrast to *Siphonaria,* an intertidal genus. One species.

33.5 *Williamia peltoides* (Carpenter, 1864). Shell small, translucent, reddish brown with white or greenish rays. Apex posterior to center, backward pointing. Length, 7-10 mm. Not uncommon at low tide and in the shallow sublittoral zone on undersides of rock. Range: Crescent City, California, to southern Mexico. I regard *W. vernalis* Dall a synonym.

Family TRIMUSCULIDAE

Nearly circular white limpet shaped shells, the siphonal groove and opening of the muscle scar on the right side.

Trimusculus Schmidt, 1818

A single species occurs in California.

33.6 *Trimusculus reticulatus* (Sowerby, 1835). BUTTON SHELL. Shell nearly circular, with central apex. Sculpture of radial and concentric ribs, margin of shell crenulate. Diameter, 12-20 mm. Found in colonies on overhung surfaces along rock ledges at about the midtide level. Range: Trinidad, California, to Acapulco, Mexico.

Class POLYPLACOPHORA

Chitons are flattened, limpet shaped animals. The shell is split into eight separate plates or valves and is enveloped laterally by the leathery girdle. The foot is prominent and the head area is small, lacking eyes and tentacles. The mantle cavity surrounds the foot and extends to the head, containing numerous pairs of gills. The anus is posterior.

Chitons are restricted to rocks or hard substrates. They have a well developed radula and graze on algae and encrusting organisms. The eastern Pacific is especially rich in chitons, but there are fewer shallow water species in southern California than in areas to the north and south.

The preparation of good chiton specimens requires special care. They must be preserved in a flattened position because of their tendency to curl. This may be done by transferring them from sea water containers, in which they have been allowed to attach, to glass slides or flat sticks and firmly wrapping with cloth tape, such as twill tape. Specimens should then be placed in alcohol for a day, after which the tape may be removed. Specimens may be returned to alcohol for preservation with the girdly fully intact, or the foot area may be scraped out and the specimens retied for drying. Although some shrinkage results, this treatment prevents curling of the girdle.

Characters useful in identifying chitons are valve shape and sculpture, color, girdle armature, and the number of insertion teeth and slits, which are apparent only in disarticulated specimens. Girdle features are best observed in specimens preserved in alcohol.

Glossary of Chiton Terms

Central areas: Anterior medial areas of intermediate valves.

Girdle: Leathery extensions of the mantle surrounding the valves, bearing armature, consisting of granules, fibrous setae, bristles, scales, spicules, or spines.

Head valve: First valve, rounded in front and lacking sutural laminae.

Insertion plates: Lateral extensions of the valves that anchor them in the girdle.

Insertion teeth and slits: Divisions of the insertion plates.

Intermediate valves: The six valves between head and tail valves.

Jugum: Dorsal ridge areas of intermediate valves.

Lateral areas: Posterior side areas on intermediate valves.

Sutural laminae: Portions of tail and intermediate valves projecting beneath the preceding valve.

Tail valve: Last valve, rounded behind and with sutural laminae in front.

Family LEPIDOPLEURIDAE

Lepidopleurids are the most primitive group of living chitons. Gills are fewer in number than in other chitons and are restricted to the posterior third of the mantle cavity. Insertion plates are either absent or when present without slitting. Most are small animals with narrow girdles.

Leptochiton Gray, 1847

Small whitish chitons with thin valves and fine granulose sculpture. Girdle with uniform, blunt scales.

34.1 *Leptochiton rugatus* (Pilsbry, 1892). A small, white, roundly arched species. The foot of living animals is dark reddish brown. Length, 10-15 mm. Fairly common at low water on the undersides of large rocks buried in sand, often associated with large specimens of *Stenoplax conspicua*. Range: Monterey Bay, California, to Camalu, northern Baja California.

Family LEPIDOCHITONIDAE

Girdle spiny or spiculose, but never with hairy setae; sculpture variable; valve surface markedly porous.

Cyanoplax Pilsbry, 1892

Valves thick, low arched, intermediate valves single slitted; girdle with minute spicules; interior of valves intensely blue or green.

34.2 *Cyanoplax hartwegii* (Carpenter, 1855). Hartweg's Chiton. Oval shaped, valves low and rounded. Color, drab gray-green, the jugal area lighter, bordered by dark longitudinal stripes. The valve surface is microscopically granular and bears scattered larger granules. Interior color of the valves is an intense blue-green. Length, 20-30 mm. Abundant on rocks in the midtidal zone, usually hidden under algae or submerged in tidepools. Range: Monterey, California, to Cedros Island, central Baja California.

Lepidochitona Gray, 1821

Small, with relatively acute arching, surface microscopically granular, girdle spinulose, narrow. Intermediate valves single slitted.

34.3 *Lepidochitona keepiana* Berry, 1948. A small species, 10-14 mm in length. Girdle set with flat-topped, crowded spicules. Coloration is variable and includes brown, gray, dark green, orange, and white, often with a mottled pattern, occasionally with diagonal markings as illustrated. Common on undersides and sides of small stones below midtide level, particularly where water is retained as the tide recedes. Range: Cayucos, California, to Rancho Socorro, northern Baja California.

Nuttallina Dall, 1871

Elongate chitons, with narrow, arched valves and a broad girdle. Valve surface coarsely granular, head valve with low radiating ribs, intermediate valves with one lateral rib. Girdle spiny, with many larger, thicker spines. Species of *Nuttallina* are found in the mid or upper intertidal zones, higher than other chitons.

34.4 *Nuttallina fluxa* (Carpenter, 1864). Valve coloration variable, chiefly dark brown, pink, and white, girdle with an alternating

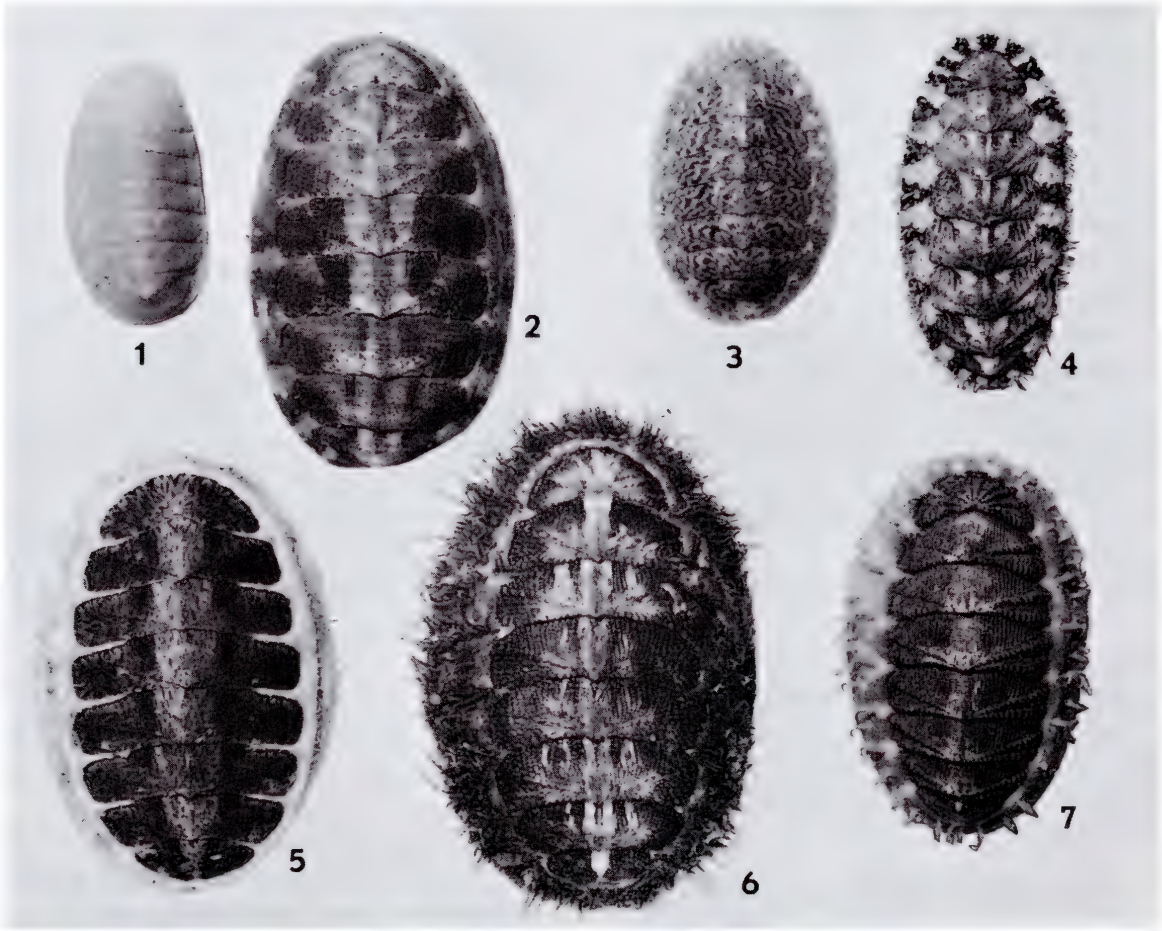

Figure 34. **1,** *Leptochiton rugatus*, x 3; **2**, *Cyanoplax hartwegii*, x 2; **3,** *Lepidochitona keepiana*, x 3; **4,** *Nuttallina fluxa*, x 1.5; **5,** *Mopalia acuta*, x 2; **6,** *M. mucosa*, x 1.5; **7,** *M. porifera*, x 2.

dark and light pattern. Spines of girdle predominantly white. Length, 25-35 mm. Common on exposed rocks. On soft rock the animals often occur in pits on the rock surface. Brightly colored, uneroded specimens may be found submerged in tidepools, and a few large individuals occur in the quiet waters of bays. Range: Point Conception, California, to Asuncion Island, central Baja California.

Family MOPALIIDAE

Head valve with eight ribs and eight corresponding slits, intermediate valves single slitted. Girdle spicular with scattered or ordered fibrous setae.

Mopalia Gray, 1847

Valves with clearly demarked lateral and central areas, sculpture of radial and longitudinal ribs. Girdle thick, always setose, broader at the sides than in front, tending to encroach between the valves at the sides. Chiefly a northern group with only a few species in southern California.

34.5 *Mopalia acuta* (Carpenter, 1855). Medium in size, dorsal ridge acute, valves flat sided, sculpture subdued, surface with fine rhomboidal pitting, a weak pustulose ridge separating the lateral and central area of the valves. Girdle encroaching between the valves on the sides, setae thin, curved, finely

branched. Color greenish gray with black and white flecks, jugal area often lighter in color, interior of valves blue. Length, 25-40 mm. Fairly common on the sides of larger rocks and boulders in the rubble reef habitat (sand beaches that expose round boulders and cobbles at low tide). Range: Monterey Bay, California, to Rancho Socorro, northern Baja California.

34.6 *Mopalia muscosa* (Gould, 1846). MOSSY MOPALIA. A relatively large species; head valve with ten beaded ribs, intermediate valves angular, flat sided; central areas with curving longitudinal sculpture, separated from the lateral areas by a pustulose rib, which bears radiating rows of coarse pustules. Color, usually dark gray or brown, with some white mottling along the middorsal line, valve interior blue. Girdle densely covered with unbranched, upright, dark brown setae. Length, 40-55 mm. Common on exposed rock surface in the mid and lower intertidal zones. Entire animal frequently overgrown with algae. Clean specimens occur on undersurfaces of rocks. Range: British Columbia to Cedros Island, central Baja California.

34.7 *Mopalia porifera* Pilsbry, 1893. Small for the genus. Head valve with ten beaded ribs, intermediate valves with convex sides, central areas with closely spaced longitudinal ridges, spaces between pitted; lateral areas with two prominent beaded ribs. Girdle spicular, with scattered, minutely branched setae. Color, gray-green with brown flecking. Length, 15-22 mm. Fairly common at low tide in the rubble reef habitat, on undersides of rocks set in fine sand. Range: Bolinas Bay, California, to Rancho Socorro, northern Baja California.

Family ACANTHOCHITONIDAE

Chitons having a narrow tegmental area, showing a partial or complete lateral encroachment of the girdle over the valves. Girdle with tufts of long spines at juncture of valves and about the head and tail valves.

Acanthochitona Gray, 1821

A single species occurs in California.

35.1 *Acanthochitona avicula* (Carpenter, 1866). Relatively small and elongate. Sculpture of incised longitudinal lines on the jugal areas and teardrop shaped pustules on the lateropleural areas. The girdle bears 18 long tufts of glassy spines in addition to dense bluish spicules. Valves finely variegated with white, brown, and gray. Length, 10-20 mm. A rather uncommon species found in partially protected intertidal areas on the sides of rocks. Range: Los Angeles County, California, to the Gulf of California.

Family ISCHNOCHITONIDAE

A group with varied sculpture patterns, but always having a scaly girdle. Head, tail, and intermediate valves have insertion slits, which are well developed in the tail valve.

Callistochiton Dall, 1879

Small chitons characterized by strong radial ribbing on head and tail valves and lateral areas of intermediate valves. Central areas with reticulate sculpture, insertion plates short, curved, slits corresponding to the ribs. Callistochitons are found chiefly in rocky areas away from fine sand and are fairly common on bryozoan-encrusted rocks in the lower intertidal and sublittoral zones.

35.2 *Callistochiton crassicostatus* Pilsbry, 1893. A narrow species with high, rounded valves. Head valve with seven strong ribs, lateral areas of intermediate valves consisting of a single, massive rib. The mucro of the tail valve projects posteriorly. Color tan or grayish. Length, 20-30 mm. Not uncommon, with other Callistochitons, at low tide and in sublittoral zones. Range: Monterey, California, to Cedros Island, central Baja California.

35.3 *Callistochiton decoratus* Pilsbry, 1893. Relatively low, roundly arched, head valve with 11 ribs, lateral areas of intermediate valves with two broad ribs, surface usually shiny, the reticulate sculpture of the central areas appearing to be polished away. Color olive green to tan, frequently with dark flecking. Length, 15-23 mm. Uncommon at low tide. Largest individuals occur in the sublittoral zone. Range: Santa Barbara, California, to Punta China, northern Baja California.

35.4 *Callistochiton palmulatus* Pilsbry, 1893. Relatively small, roundly arched, head

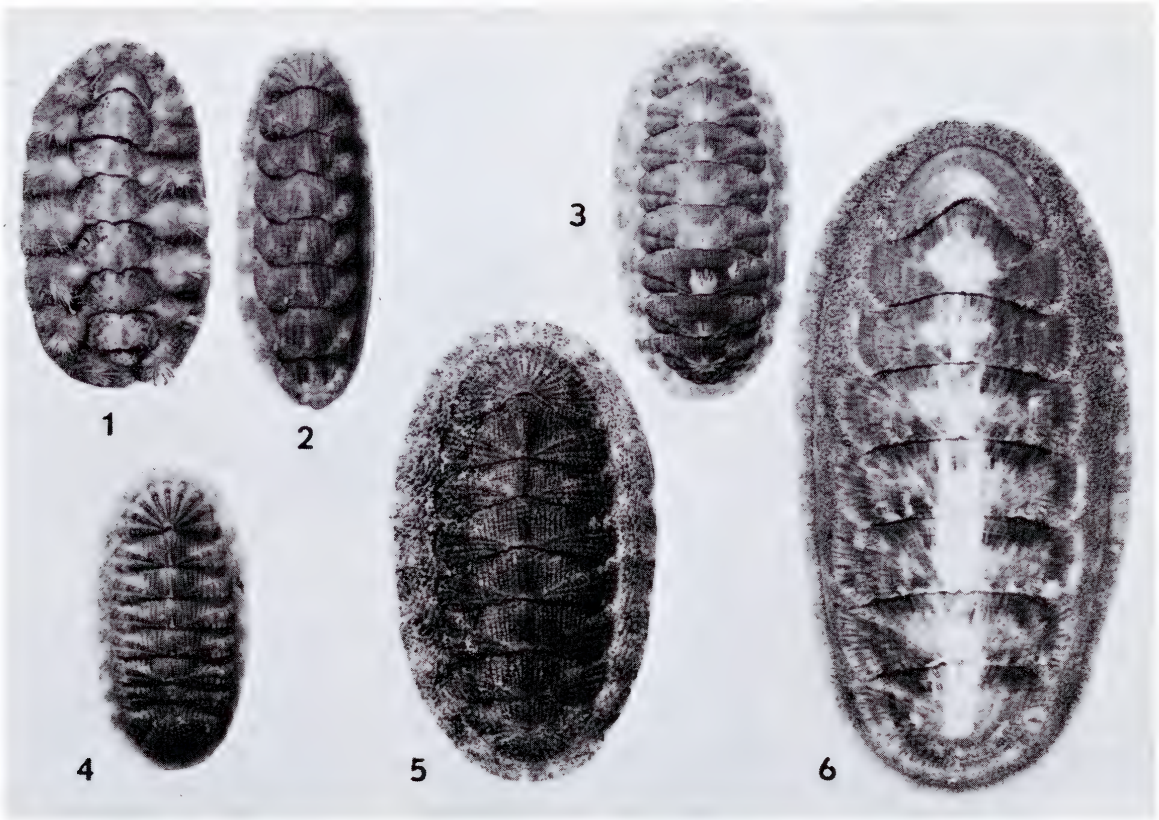

Figure 35. **1,** *Acanthochitona avicula,* x 2; **2,** *Callistochiton crassicostatus,* x 2; **3,** *C. decoratus,* x 2; **4,** *C. palmulatus,* x 2; **5,** *Lepidozona californiensis,* x 2; **6,** *Stenoplax conspicua,* x 1.5.

valve of juveniles with nine and adults 11 pustulose ribs, lateral areas of intermediate valves with two strong ribs, the massively ribbed area of the tail valve raised in large specimens. Color light brown, some specimens with gray-green flecking. Length, 10-15 mm. Range: Monterey Bay, California, to Santo Tomas, northern Baja California.

Lepidozona Pilsbry, 1892

Sculpture of the intermediate valves consists of longitudinal ribs on the central areas and beaded radial ribbing on the lateral areas, tail valve neither raised nor depressed, girdle bearing calcareous rhomboidal scales.

35.5 *Lepidozona californiensis* Berry, 1931. Head valve has about 20 low beaded ribs, central areas have strong longitudinal and transverse ribbing with square pits between; lateral areas with 5-6 beaded ribs. Color, greenish brown or muddy orange with darker flecking, girdle colors matching valve colors and showing alternating light and dark areas. Length, 20-30 mm. Common on undersurfaces and sides of rocks at low tide and in the sublittoral. Range: Los Angeles County, California, to Magdalena Bay, Baja California.

Stenoplax Dall, 1879

Large, elongate chitons, head valves often concave, intermediate valves with nearly smooth central areas and raised lateral areas, tail valves elongate, depressed. Members of this genus live on rocks resting in sand. During daylight hours they are found below the level of the sand.

35.6 *Stenoplax conspicua* (Pilsbry, 1892). CONSPICUOUS CHITON. A large chiton having a girdle bearing elongate spiny scales. Intermediate valves with two to four slits. Color usually greenish, middorsal area often eroded to show the pink of deeper shell layers, inte-

rior of valves blue with pink along the midline. Length, 50-90 mm. Range: Santa Barbara County, California, to the Gulf of California.

Class PELECYPODA

Pelecypods or bivalves include the clams, mussels, and scallops. As the second largest class, they have spread extensively in both salt and fresh water. Soft parts are enclosed within two shell valves, and the head and some sensory structures are lost. Bivalves may attach to a hard substrate, nestle in crevices, burrow in soft bottoms, or bore into rock. The foot is adapted for burrowing rather than gliding.

Valves are joined by a hinge area, which may have articulating teeth, preventing rotation of the valves, and a horny or fibrous structure, the ligament, connecting the valves. The placement of the ligament whether under tension or compression tends to open the valves slightly. The valves are closed by contraction of the adductor muscles connecting the valves.

Bivalve gills are large and well developed. Small cilia on the gill surfaces beat in unison and move large volumes of water through the mantle cavity. Food consists of plankton and detrital material filtered from the water. Food particles are collected on the gills and passed to the mouth. Deep burrowing clams have paired siphons extending to the substrate surface, one a channel for incoming currents bringing food, the other for expelling water and waste.

Several orders of pelecypods are recognized, but only the two largest orders, Filibranchia and Eulamellibranchia, occur in relatively shallow water. Filibranchs are sessile or attached forms such as mussels, oysters, and swimming scallops. Eulamellibranchs are generally burrowing forms with long siphons. Offshore groups not treated include protobranchs and septibranchs.

Correct orientation of the pelecypod valve is necessary to an understanding of shell descriptions. In this book all illustrations are of the outer surface of the left valve and part of the inner surface, including the hinge area, of the right valve. Anterior and posterior ends of single valves can be determined by position of several structures in relation to the centrally positioned beaks. The ligament is always posterior to the beak, as is the pallial sinus, if present. In living individuals the foot and byssus project anteriorly, the siphons posteriorly.

Characters useful in the identification of bivalves include shell shape and sculpture, hinge dentition, structure and position of the ligament, and shape of the pallial sinus.

Glossary of Bivalve Shell Terms

Adductor muscle scars: Attachment scars of one or two large muscles that close the valves.

Anterior end: Front end of valve, through which foot and byssus, if present, protrude.

Beak: Tip, or first formed part of the shell, above the hinge area.

Byssus: Tough, fibrous threads secreted by the foot of some bivalves for permanent or temporary attachment.

Cardinal teeth: Central teeth of hinge plate, directly below the beaks.

Chondrophore: Spoon shaped shelf in the hinge for support of an internal ligament.

Concentric sculpture: Ribbing congruent with margin or growing edge of shell.

Escutcheon: Depressed or smooth area behind the ligament in some bivalves.

Gape: Opening along valve margin when valves are shut. In some bivalves the foot, byssus or siphons project through a gape in the shell.

Hinge: Dorsal, articulating margin of the valves, location of teeth and ligament.

Lateral teeth: Hinge teeth anterior or posterior to cardinal teeth.

Ligament: A horny or fibrous band connecting the valves behind the beaks, internal or external.

Lunule: A heart shaped depressed area in front of the beaks in some bivalves.

Pallial line: A scar line connecting the two adductor muscles, marking attachment of mantle margin to the shell.

Pallial sinus: A posterior indentation in the pallial line marking attachment area of the siphonal muscles in bivalves having long siphons.

Posterior end: Hind end of the valve, through which the siphons protrude.

Radial sculpture: Ribbing that diverges from beaks to shell margins.

Umbo: Upper part of shell as seen in lateral view, above hinge margin.

Valve: One of the left or right halves of the bivalve shell.

Order FILIBRANCHIA

Filibranchs are mostly sessile or sedentary. Some, like the mussels, attach to hard substrates with the byssus, others, such as oysters, cement the lower valve to the substrate. Scallops have developed motility, effecting a crude swimming movement. The gill is elongate and folded back upon itself and is held against the adjoining fold by interlocking cilia. Hinge structure is relatively simple. The dentition may be taxodont, consisting of a long row of similar interlocking teeth, as in the ark shells, or chiefly of articulating ridges on the hinge, as in most filibranchs. In this group there is an evolutionary tendency toward reduction and loss of the anterior adductor muscle. This may be observed in the progression from Arcidae, with two equal adductors, to Mytilidae, with the anterior adductor much smaller, to oysters and scallops, with no anterior adductor.

Family ARCIDAE

Arks have solid porcelaneous shells with numerous undifferentiated teeth on a long hinge, anterior beaks, and the ligament mainly external in grooves in the cardinal area between beaks. The adductor scars are equal in size and the pallial line is entire. Most species attach to the substrate by a byssus protruding through the ventral margin of the shell. The Arcidae are primarily tropical, with only one species occurring in southern California.

Barbatia Gray, 1842

Small shells with cancellate sculpture and a narrow ligamentary area, posterior to the beaks.

36.1 *Barbatia bailyi* (Bartsch, 1931). BAILY'S ARK. A small tan shell with a fine periostracum, coarse sculpture, and prominent muscle scars. Length, 9 mm. Common on the undersurfaces of rocks at low tide, attached by byssal threads. Range: Santa Monica, California, to Panama.

Family MYTILIDAE

Mussels have the beaks placed anteriorly and the posterior end rounded. Hinge line long, ligament internal, no strong articulating hinge teeth. Anterior adductor scar much reduced, posterior adductor scar large. Like the ark shells, mussels attach to the substrate by byssal threads projecting from the ventral edge of the shell.

Mytilus Linneaus, 1758

Posterior end of shell inflated, and anterior margin bearing small teeth.

36.2 *Mytilus californianus* Conrad, 1837. CALIFORNIA MUSSEL. Thick shelled, covered with a heavy periostracum, showing strong radial ribs and irregular growth lines, the surface usually worn. Interior blue-black, dark at the margins. Length, 80-130 mm. Abundant in masses in the upper intertidal, attached by byssal threads, on surf exposed rocks. Range: Aleutian Islands, Alaska, to southern Baja California.

36.3 *Mytilus edulis* Linnaeus, 1758. BAY MUSSEL. Relatively thin shelled, nearly smooth, with a black periostracum and three small teeth at the beaks. Length, 70-100 mm. Common at low tide within bays and in sheltered areas, attached in masses to pilings or rocks. Range: Arctic Ocean to southern Baja California, also in the North Atlantic, and along South America, and Australia.

Septifer Récluz, 1848

Small shells sculptured with strong radiating ridges. Anterior tip of each valve hinged within by a shelly deck.

36.4 *Septifer bifurcatus* (Conrad, 1837). A small black species with radiating ribs that are fine and closely spaced on the anterior

Figure 36. **1,** *Barbatia bailyi*, x 4; **2,** *Mytilus californianus*, x 1; **3,** *M. edulis*, x 1; **4,** *Septifer bifurcatus*, x 1.5; **5,** *Modiolus capax*, x 1; **6,** *M. rectus*, x .7.

ventral surface, stronger on the posterior dorsal surface. Interior purple, posterior margin crenulate. Length, 20-32 mm. Common at low tide attached to the undersurfaces of boulders. Range: Crescent City, California, to Cape San Lucas, Baja California.

Modiolus Lamarck, 1799

Horsemussels are large forms with beaks somewhat behind the anterior tip of the shell. Most species have coarse periostracal hairs. Listed as *Volsella* in older works.

36.5 *Modiolus capax* (Conrad, 1837). CAPAX HORSEMUSSEL. Large and inflated, with a dark periostracum that is lighter colored on a small ventral area. Dorsal area covered with dense, serrate periostracal hairs. Shell reddish under the periostracum, interior white. Length, 60-100 mm. Common in masses on pilings within bays, solitary individuals occur in protected areas along the open coast, at low water and in the shallow sublittoral. Range: Santa Cruz, California, to Peru.

36.6 *Modiolus rectus* (Conrad, 1837). STRAIGHT HORSEMUSSEL. A large, elongate, thin shelled species. Dorsal posterior surface tan with a fringed periostracum, anterior ventral surface smooth, with glossy dark brown periostracum. Shell bluish underneath. Length, 70-120 mm. Not common, living singly on mud flats at low water or submerged, with the posterior end slightly protruding. Range: Vancouver Island, British Columbia, to the Gulf of California.

Geukensia Van der Poel, 1959

Similar to *Modiolus*, but with strong radial ribbing and no periostracal hairs. One species occurs in California.

37.1 *Geukensia demissa* (Dillwyn, 1817). RIBBED MUSSEL. Characterized by regular radial ribs on the dorsal posterior surface, reflected on the inner surface of the valve. Periostracum dark brown, glossy, interior metallic purple. Length, 60-100 mm. Introduced from the east coast, it is known only from San Francisco Bay, Upper Newport Bay, and the Los Angeles Harbor near Long Beach, where it may be found in the mid to upper intertidal zone on mud.

Adula H. and A. Adams, 1857

Elongate cylindrical shells, beaks just back of anterior end, periostracum well developed. With the exception of *Adula diegensis*, all are borers in soft rock. *Adula* was considered a subgenus of *Botula*, but is now accorded generic rank.

37.2 *Adula diegensis* (Dall, 1911). SAN DIEGO PEA-POD. Small, with an oblique ridge extending posteriorly from the umbones. Area of lunule with fine radiating lines forming internal ridges. Color glossy brown, interior with a metallic blue iridescence. Length, 16-24 mm. A non boring species, commonly nestled with *Mytilus californianus* along breakwaters and pilings, close to open water. Range: Oregon to the Gulf of California.

37.3 *Adula falcata* (Gould, 1851). FALCATE DATE MUSSEL. Shell elongate and fragile with a prominent oblique ridge. Periostracum chestnut brown, glossy, worn at the beaks, surface covered with fine striae or wrinkles. Interior metallic gray, with weak green iridescence. Length, 50-80 mm. A borer in soft shale, often found in areas with pholads. Range: Coos Bay, Oregon, to Baja California.

Lithophaga Röding, 1798

Date mussels are elongate rock boring clams that bore into soft shale or shells of mollusks. Boring is accomplished by rotation of the shell.

37.4 *Lithophaga plumula* (Hanley, 1843). DATE MUSSEL. Anterior end rounded, two grooves extending from beaks to the tapered posterior end of the shell, area between the grooves bearing a ridged, feathery encrustation extending posteriorly beyond end of shell, encrustation is also thinly spread over the rest of the shell. Periostracum glossy brown under the encrustation, interior metallic gray. Length, 40-55 mm. Fairly common boring into soft shale and mollusk shells, at low tide and in sublittoral depths. Range: Mendocino County, California, to Peru.

Family OSTREIDAE

Oysters attach to hard substrates by the left valve and assume an irregular growth form. They are characterized by an internal ligament and a single central adductor muscle scar. Some form extensive beds and are valued for food.

Ostrea Linnaeus, 1758

Valves nearly equal in size, muscle scar not dark colored. A single species is native to southern California.

37.5 *Ostrea lurida* Carpenter, 1864. NATIVE OYSTER. A flat, thin shelled species, irregular in shape, with a foliated surface. Color, gray-white, with some dark markings, interior whitish. Length, 45-60 mm. Common in bays, attached to rocks, cement pilings, or oyster shell on mudflats. Range: Sitka, Alaska, to southern Baja California.

Family PECTINIDAE

Pectens or scallops are a large, diverse family occurring in all seas. The shell is nearly circular in outline, except for two triangular projections called ears along the straight hinge line. No cardinal teeth, although there may be some articulating folds along the hinge margin. The internal ligament is triangular, and there is a single large central adductor muscle scar in each valve. Scallops are able to effect a clumsy swimming movement by contracting the valves and forcing out water. Young shells may attach to the substrate with the byssus,

Figure 37. **1,** *Geukensia demissa*, x 1; **2,** *Adula diegensis*, x 2; **3,** *A. falcata*, x 1; **4,** *Lithophaga plumula*, x 1; **5,** *Ostrea lurida*, x 1.

which projects from a notch under the anterior ear of the right valve. The right valve, more inflated than the left in some species, rests on the sea floor in the free swimming forms, or is the lower or attached valve in sessile forms or those attached by the byssus. Color may differ between valves, the left or upper valve is usually darker.

Aequipecten Fischer, 1886

Valves convex, strongly ribbed, anterior and posterior ears about equal in size, raised concentric growth lines in spaces between ribs.

38.1 *Aequipecten aequisulcatus* (Carpenter, 1864). SPECKLED SCALLOP. A relatively large shell having about 19-22 flattened radial ribs with interspaces of equal width. Color, gray-white or yellow-orange, with darker mottling of reddish brown, left valve darker. Diameter, 60-80 mm. Occurs on sandy or muddy bottoms of bays and lagoons below low tide level, occasionally on quiet bottoms of the open coast. Range: Santa Barbara, California, to southern Baja California. This is usually considered as a northern subspecies of the Panamic species *A. circularis*, which is smaller, more inflated, more colorful, and rounder. Until a subspecific relationship can be demonstrated, I am regarding them as separate species.

Chlamys Röding, 1798

Valves equal in size, with scaly or spinose ribs, posterior ears reduced. Usually attached with the byssus.

38.2 *Chlamys hastata* (Sowerby, 1842). SPEAR SCALLOP. Valves moderately inflated, left valve with about 10 strong spinose ribs, right valve with nine strong double or paired ribs, paired ribs well spaced, both valves with fine intercalary ribs and fine imbricate sculp-

ture throughout. Anterior ears much larger than posterior, byssal notch of right valve deep. Color yellow to pink, left valve darker. Width, 35-60 mm. On rocky bottoms, in sublittoral depths of 60 feet and deeper, not common. Range: Alaska, to San Diego, California.

Leptopecten Verrill, 1897

Similar to *Aequipecten* but valves thin, flatter, only slightly concave.

38.3 *Leptopecten latiauratus* (Conrad, 1837). Shell small, thin, hinge line long, ribs 12-16, flat topped, concentric lamellae strong. Color, brownish, with diagonal markings of white and darker brown. Diameter, 10-20 mm. Occasionally found attached to rocks or pilings in bays, and on offshore bottoms attached to worm tubes or debris. Range: Point Reyes, California, to Cape San Lucas and the Gulf of California.

38.4 *Leptopecten monotimeris* (Conrad, 1837). KELP SCALLOP. Larger than *L. latiauratus*, the ribs are rounded and concentric lamellae are absent. Color, yellow or orange-brown, with diagonal or chevron shaped markings of white and darker brown. Diameter, 20-30 mm. Common, attached to giant kelp in open water, eelgrass in bays, less frequently to rocks. Range: Santa Barbara County, California, to southern Baja California. This species is often listed as a subspecies of the preceding, but it is distinct.

Hinnites Defrance, 1821

Early stage with the *Chlamys* shell form, right valve of adult attached to substrate, distorted to fit. A single eastern Pacific species.

38.5 *Hinnites multirugosus* (Gale, 1928). ROCK SCALLOP. Juvenile shell yellowish, to one inch in length, similar to *Chlamys hastata*, right valve with paired major ribs, left valve singly ribbed. Valves of mature shell thick and heavy, sculpture of coarsely imbricated ribs. Color, brownish, interior white, hinge area with a deep purple stain. Diameter, 60-150 mm. Ten inch specimens have been recorded. Common, low tide and sublittoral, on pilings in bays and along the outer coast, the largest specimens from depths of 70 feet or more. Juvenile specimens are free swimming. Range: Queen Charlotte Islands, British Columbia, to Point Abreojos, central Baja California.

Pecten Müller, 1776

Right valve convex, left valve flat or slightly concave, darker in color, ears nearly equal in size, byssal notch small, ribs strong, smooth. Primarily a tropical genus, one species occurs in California.

38.6 *Pecten diegensis* Dall, 1898. SAN DIEGO SCALLOP. Relatively large, right valve convex, left valve only slightly convex, with approximately 22 flattened ribs, broader on the right or lower valve. Right valve yellow, left valve orange or reddish, often with white maculations. Diameter, 50-100 mm, only rarely reaching 140 mm. Occasionally taken on rocky bottoms by divers, 60 feet and deeper. Range: Bodega Bay, California, to Cape San Lucas, Baja California.

Family LIMIDAE

File shells are white shells similar to the scallops, but have poorly developed ears and are more asymmetrical. The animals have long tentacles and are motile like the scallops but are not highly active.

Lima Bruguière, 1797

Oblique ovate shells. One species occurs in shallow water.

39.1 *Lima hemphilli* Hertlein and Strong, 1946. FILE SHELL. White, with fine radial sculpture, valves with an anterior and a posterior gape. Diameter, 20-30 mm. Not uncommon on rocky bottoms at depths below 30 feet. Range: Monterey Bay, California, to Acapulco, Mexico. Synonym, *L. dehiscens* of authors, not of Conrad.

Family ANOMIIDAE

Jingle shells have translucent valves attaching by a thick byssal plug projecting through a rounded opening near the hinge of the lower or right valve. The ligament is internal; no dentition. The single adductor is split into two or three closely adjacent muscles that leave well marked attachment scars in the upper or unattached valve. Shell form is irregular, tak-

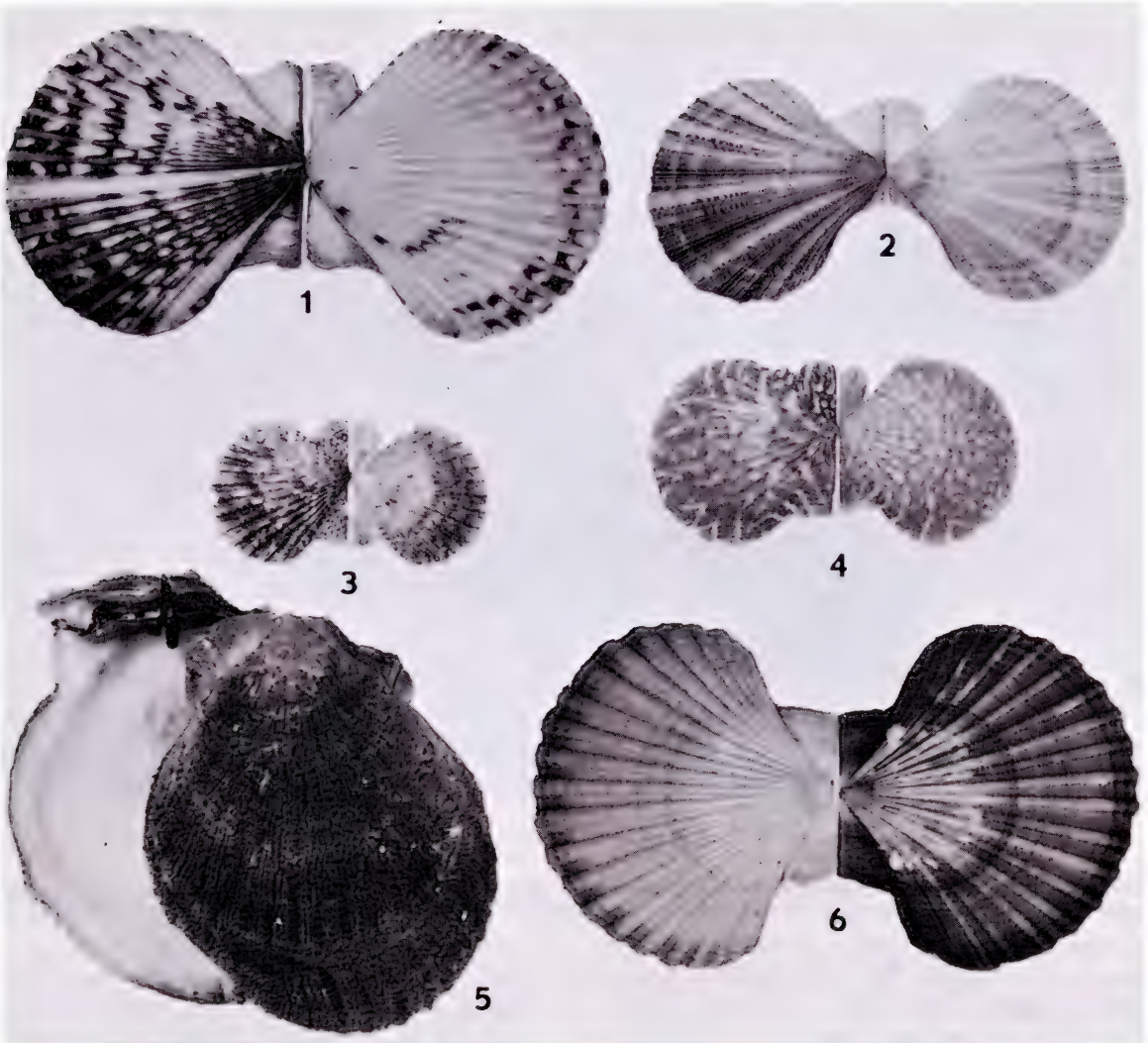

Figure 38. **1,** *Aequipecten aequisulcatus*, x .7; **2,** *Chlamys hastata*, x .7; **3,** *Leptopecten latiauratus*, x 2; **4,** *L. monotimeris*, x 1; **5,** *Hinnites multirugosus*, x .5; **6,** *Pecten diegensis*, x .7.

ing on the configuration and sculpture of the substrate.

Anomia Linnaeus, 1758

Shells having three muscle attachment scars in the upper valve. One species occurs in southern California.

39.2 *Anomia peruviana* Orbigny, 1846. PEARLY JINGLE. A thin shelled form, with a foliated surface lacking sculpture of its own, but assuming the sculpture of the substrate. Color, pale white, greenish, yellow, or orange. Diameter, 40-60 mm. Common on clam shells and rock off exposed beaches along the open coast, seldom taken alive, but the worn upper valves are commonly found on beaches. Range: Monterey Bay, California, to Peru.

Pododesmus Philippi, 1837

Jingle shells characterized by having two adjacent muscle scars. Two species occur in southern California.

39.3 *Pododesmus cepio* (Gray, 1850). ABALONE JINGLE. Larger and thicker shelled than *Anomia peruviana*, the shell is sculptured with irregular, branching radial ribs and has two muscle scars. Color, gray-white, interior green or gray-green. Diameter, 50-80 mm. Common on shells of abalone and on sub-

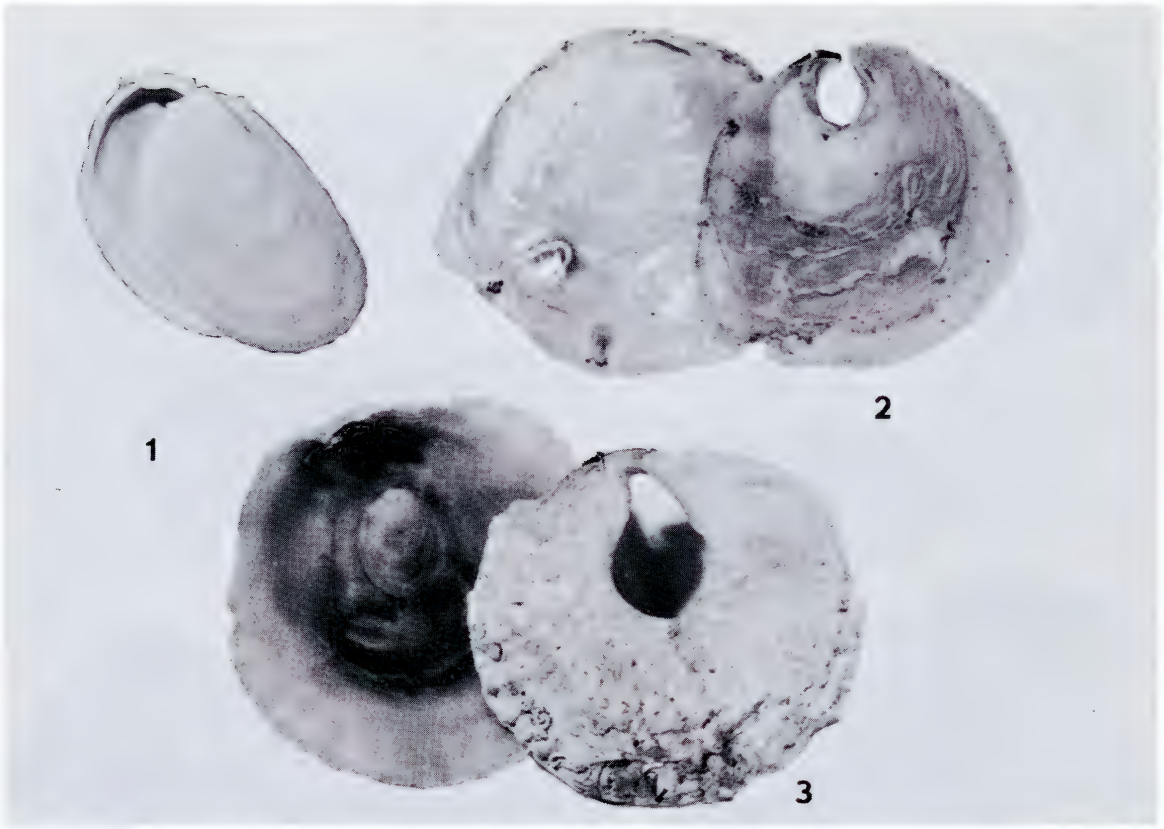

Figure 39. **1,** *Lima hemphilli*, x 2; **2,** *Anomia peruviana*, x 1; **3,** *Pododesmus cepio*, x 1.

merged reefs, particularly common on breakwater rocks. Range: British Columbia to the Gulf of California. Listed in older works as *P. macrochisma* (Deshayes, 1839), a name applicable to an Alaskan species. *Pododesmus pernoides* (Gray, 1853) is less common and has a brownish interior.

Order EULAMELLIBRANCHIA

Eulamellibranchs constitute the largest and most diverse group of bivalves. They differ from the filibranchs chiefly in the structure of the gills, in that the adjoining folds are held together by interlocking cross channels of tissue, rather than cilia. All eulamellibranchs have two nearly equal sized adductor muscles. Hinge dentition and ligament structure become increasingly complex. Less specialized members may be sessile, as in the chamas, or may nestle in crevices with a small byssus. More advanced members are deep burrowing and have long siphons. There is an tendency for the valves to become markedly inequivalve and some highly specialized forms have lost the strong cardinal dentition. Rock boring pholads have developed accessory shelly plates that strengthen the shell.

Family CHAMIDAE

The Chamidae attach by one valve that is deeply convex, the upper valve is nearly flat. Sculpture consists of radiating rows of scales or spines. The hinge, with a single major crenulated tooth in each valve, fits into a corresponding pit in the other valve. The ligament is external and continues in a spiral groove to the umbones. The two adductor scars are joined by a simple pallial line. Primarily a tropical group, few species occur in temperate regions.

Chama Linnaeus, 1758

Always attached by the left valve, thus the spiral line from the beak is counterclockwise.

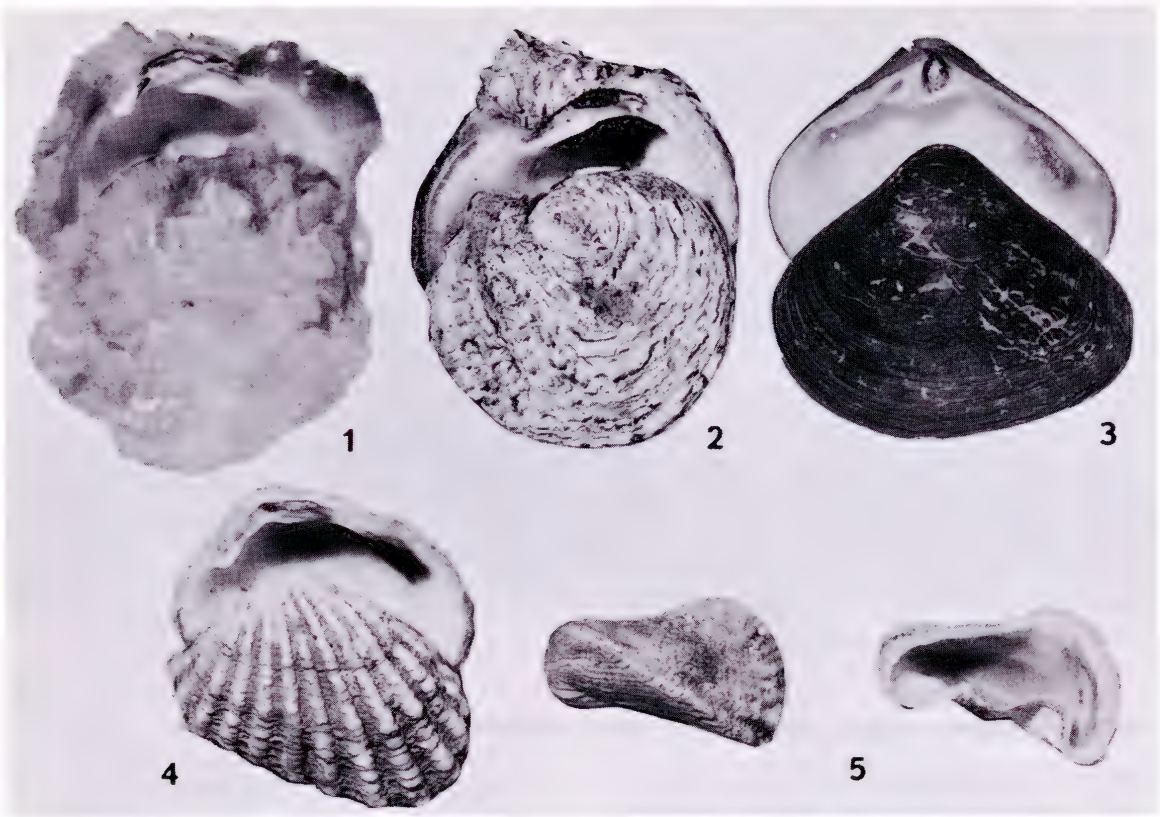

Figure 40. **1,** *Chama pellucida,* x 1; **2,** *Pseudochama exogyra,* x 1; **3,** *Crassatella fluctuata,* x 1; **4,** *Glans subquadrata,* x 4; **5,** *Milneria kelseyi,* x 4.

40.1 *Chama pellucida* Broderip, 1835. AGATE CHAMA. A white shell often tinged with pink or orange, with broad, translucent frills. Diameter, 40-60 mm. Common in bays, attached to rocks and pilings, and on submerged offshore reefs. Best developed specimens are found on shaded pilings at low tide. Range: Oregon to southern Baja California.

Pseudochama Odhner, 1917

Attached by the right valve, thus the spiral line from the beak is clockwise.

40.2 *Pseudochama exogyra* (Conrad, 1837). REVERSED CHAMA. Recognized by its clockwise spiral, the shell is usually smaller and the sculpture more subdued than that of *Chama pellucida.* Diameter, 30-50 mm. Strictly an intertidal species characteristic of the open coast, common on rocky reefs at about the midtide level. Range: Oregon to southern Baja California.

Family CRASSATELLIDAE

Trigonal shells with nearly central beaks, sculpture of concentric undulations, at least in juvenile shells. Ligament internal, triangular, two cardinal teeth in each valve, no lateral teeth, but lateral ridges developed. Pallial line entire, connecting two nearly equal adductor scars.

Crassatella Lamarck, 1799

Medium sized thick shells with a dark brown periostracum, concentric sculpture missing on mature shells. One species occurs in southern California.

40.3 *Crassatella fluctuata* (Carpenter, 1864). Undulating sculpture only on the umbones, the periostracum dark brown, lunule and escutcheon offset by lighter colored periostracum. Posterior end of shell slightly constricted, interior white, posterior muscle scar stained brown. Length, to 44 mm. A relatively uncommon species, loose valves have been

found on rocky sublittoral bottoms, particularly at Catalina Island. Range: Santa Barbara Island to Catalina Island, California.

Family CARDITIDAE

Carditas have beaks near the anterior end of the shell, a hinge with one or two cardinal teeth, some genera with lateral teeth, ligament external, sculpture of strong ribbing, pallial line entire.

Glans Megerle von Mühlfeld, 1811

Small shells with lateral teeth. One species.

40.4 *Glans subquadrata* (Carpenter, 1864). A stout little shell, with 15-17 strong, beaded ribs, and a crenulate margin. Color, tan with brown mottling under a fine periostracum. Interior white with brown markings in the dorsal posterior area. Length, 7-10 mm. Common, attached to the undersurfaces of rocks at low tide and in sublittoral depths. Range: Queen Charlotte Islands, British Columbia, to Camalu, northern Baja California. Listed in some works as *G. carpenteri* (Lamy, 1922) an invalid replacement name.

Milneria Dall, 1881

Small quadrate shells, beaks at the anterior end, ventral surface of the female shell with a rounded indentation serving as a brood pouch, closed only by an extension of the periostracum across this area.

40.5 *Milneria kelseyi* Dall, 1916. Shell with strong carina running from the beaks to posterior ventral margin, dorsal surface with fine imbricate ribs. Base of shell nearly flattened, brood pouch prominent. Length, 6-8 mm. Common, attached by byssus on the undersurfaces of rocks at low tide. Range: Monterey Bay, California, to Punta Abreojos, central Baja California.

Family ERYCINIDAE

Small shells with fine concentric sculpture, hinge with a variable number of teeth, ligament internal, pallial line entire, margin smooth. Most species are nestlers or are commensal with other invertebrates, attached by a byssus.

Lasaea Brown, 1827

Minute reddish shells, hinge with cardinal and lateral teeth, sculpture of fine concentric ridges.

41.1 *Lasaea subviridis* Dall, 1899. One of the smallest of clams, length, about 2 mm. Beaks posterior to center; hinge and upper part of shell reddish. Common along the open coast, nestling among byssal threads in *Mytilus* beds. Range: Humboldt County, California, to Ensenada, northern Baja California.

Family KELLIIDAE

Inflated shells with an internal ligament, two cardinal teeth in the left valve, one in the right, posterior lateral teeth, but no anterior laterals, pallial line entire.

Kellia Turton, 1822

One southern California species.

41.2 *Kellia laperousii* Deshayes, 1839. Beaks nearly central, sculpture of fine concentric growth lines, shell covered with a translucent yellow periostracum. Length, 10-25 mm. Common, nestled on wharf pilings, mussel beds, and rocks, at low tide and sublittoral depths. Range: Bering Sea, Alaska, to the Gulf of California.

Family LUCINIDAE

Solid disk shaped shells with nearly central beaks, characterized by an external ligament in a long pit, an elongate anterior muscle scar, and an entire pallial line.

Epilucina Dall, 1901

Sculpture of fine concentric lamellae, both valves with two cardinal teeth, anterior and posterior lateral teeth. One species in California.

41.3 *Epilucina californica* (Conrad, 1837). California Lucine. A whitish, medium sized shell with fine, even concentric ridges, a low ridge extending posteriorly from the beaks; area of lunule small, provided by the right valve. Diameter, 20-35 mm. Common, living in gravel in rocky areas, low tide and at sublittoral depths. Range: Crescent City, California, to San Ignacio Lagoon, central Baja California.

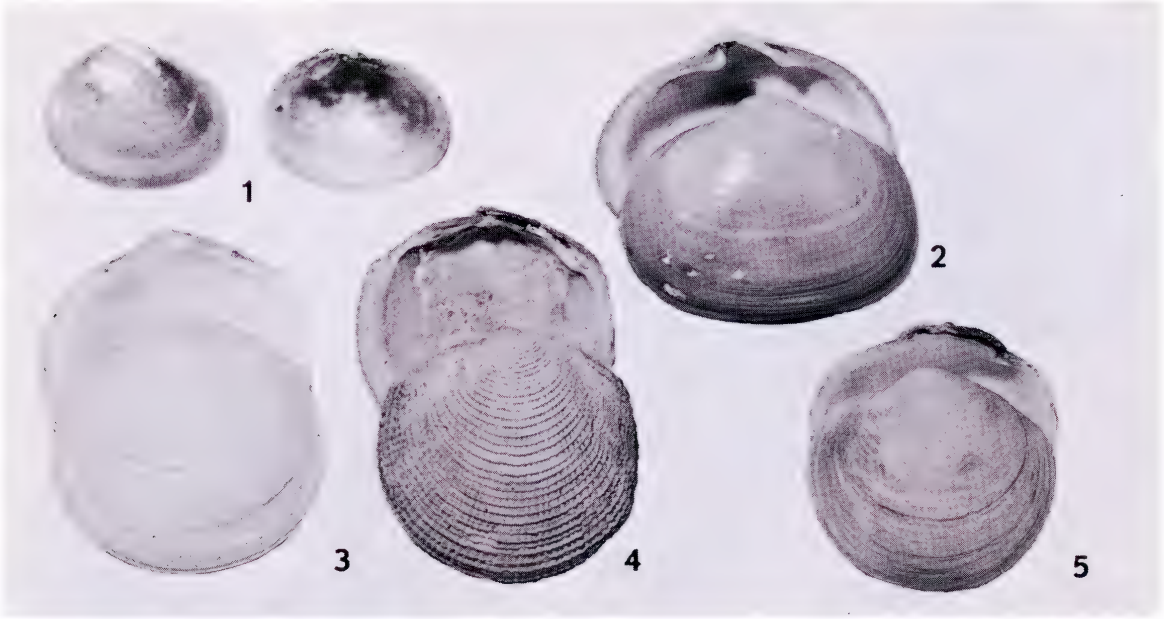

Figure 41. **1,** *Lasaea subviridis*, x 12; **2,** *Kellia laperousii*, x 1.5; **3,** *Epilucina californica*, x 1.5; **4,** *Lucinisca nuttalli*, x 1.5; **5,** *Diplodonta orbellus*, x 1.5.

Lucinisca Dall, 1901

Radial and concentric sculpture about equal, strong, somewhat spiny. Cardinal and lateral teeth are present. One Californian species.

41.4 *Lucinisca nuttalli* (Conrad, 1837). NUTTALL'S LUCINE. Radial ribs are numerous and the sculpture is strongly cancellate. Lunule short and deeply impressed. Length, 15-20 mm. Not uncommon on sandflats at low tide and offshore. Range: Monterey, California, to the Gulf of California and Tres Marias Islands, Mexico.

Family UNGULINIDAE

Small, globular shells with large adductor scars and an entire pallial line, ligament external, two cardinal teeth in each valve, no lateral teeth.

Diplodonta Bronn, 1831

Posterior cardinal teeth in each valve are bifid. These clams form a nest of sand cemented by mucus.

41.5 *Diplodonta orbellus* (Gould, 1851). Nearly spherical in shape, the shell shows concentric growth lines under a dark yellow periostracum. Length, 20-30 mm. Fairly common under rocks in the intertidal and sublittoral zones, usually in a nest of agglutinated rubble. Range: Pribilof Islands, Alaska, to the Gulf of California.

Family CARDIIDAE

Cockles or heart clams have beaks anterior to center, shells usually sculptured with radiating ribs that may interlock along the margins as deep marginal crenulations. Hinge with projecting paired cardinal teeth, anterior and posterior lateral teeth in most genera. Muscle scars equal, pallial line entire. Cockles live on sand or mudflats at low tide and deeper, partially buried, with their short siphons projecting. The well developed foot is capable of rapid movement.

Americardia Stewart, 1930

The posterior slope of the shell is set off by a ridge; in cross section the ribs are straight sided.

42.1 *Americardia biangulata* (Broderip and Sowerby, 1829). Sculptured with 27-28 broad flattened ribs. Color, brownish yellow or orange with white mottling, interior white with a purple stain. Length, 25-35 mm. Fairly common on sublittoral gravel near rock,

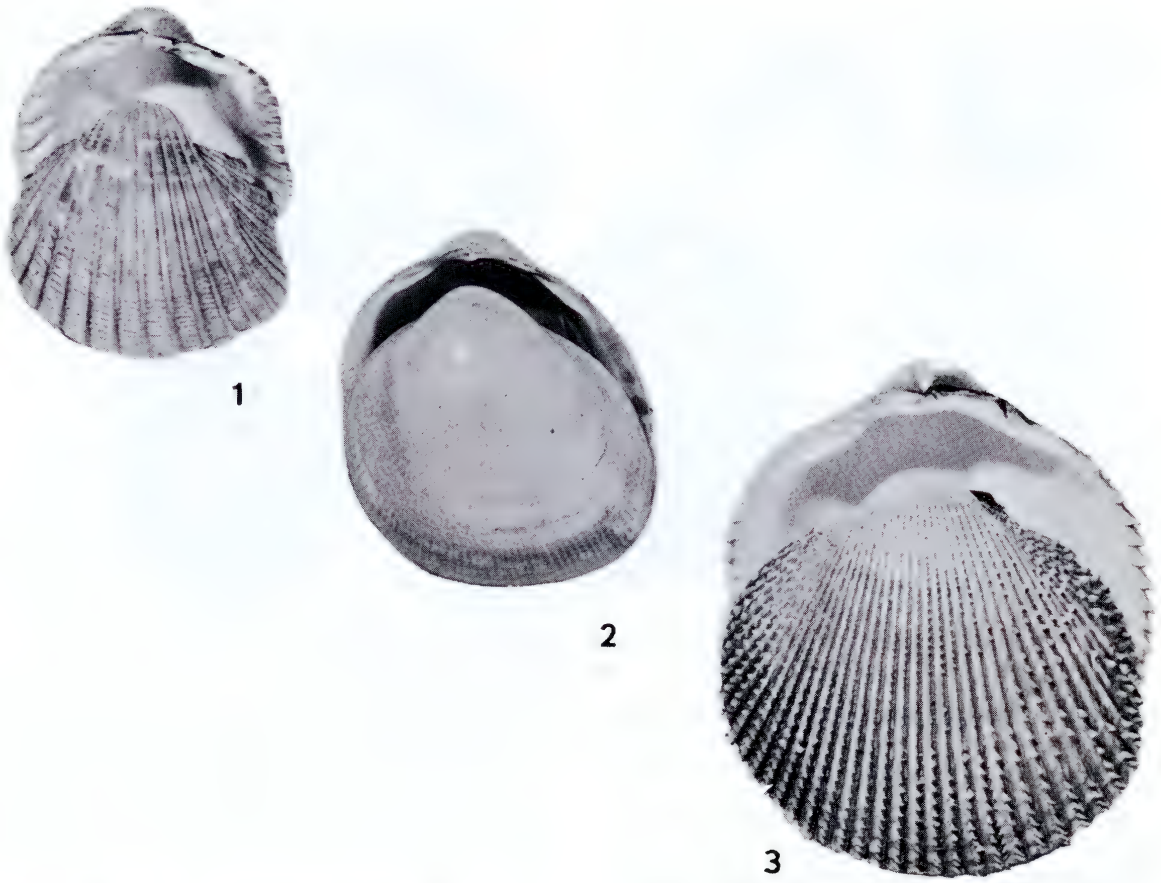

Figure 42. **1,** *Americardia biangulata*, x 1; **2,** *Laevicardium substriatum*, x 1.5; **3,** *Trachycardium quadragenarium*, x .7.

particularly at the offshore islands. Range: Redondo Beach, California, to Ecuador.

Laevicardium Swainson, 1840

Shell smooth or finely ribbed, margin with weak crenulations that are lacking posteriorly.

42.2 *Laevicardium substriatum* (Conrad, 1837). Egg Cockle. Relatively small, with thin, nearly smooth valves. Color, pale yellow or gray, flecked with brown, interior pattern similar, but with darker brown staining. Length, 20-37 mm. Common on sand bottoms or sloping banks at low tide in bays and offshore. Range: Mugu Bay, California, to southern Baja California.

Trachycardium Mörch, 1853

Relatively large shells with strong scaly or spiny ribs.

42.3 *Trachycardium quadragenarium* (Conrad, 1837). Spiny Cockle. Shell large, with 41-44 strong radial ribs, each with a row of triangular spines. Margin deeply crenulate, interior with grooves corresponding to ribs. Color yellow-brown, interior white. Length, 50-80 mm. Fairly common on sandflats of bays and on sandy bottoms offshore. Range: Monterey Bay, California, to southern Baja California.

Family VENERIDAE

Venus clams are solid shells with beaks anterior to center and directed forward. Ligament elongate, external, set in a deep groove. Hinge with three cardinal teeth in each valve, left valve of some genera with an anterior lateral tooth, set in a corresponding groove in the right valve. Sculpture is primarily concen-

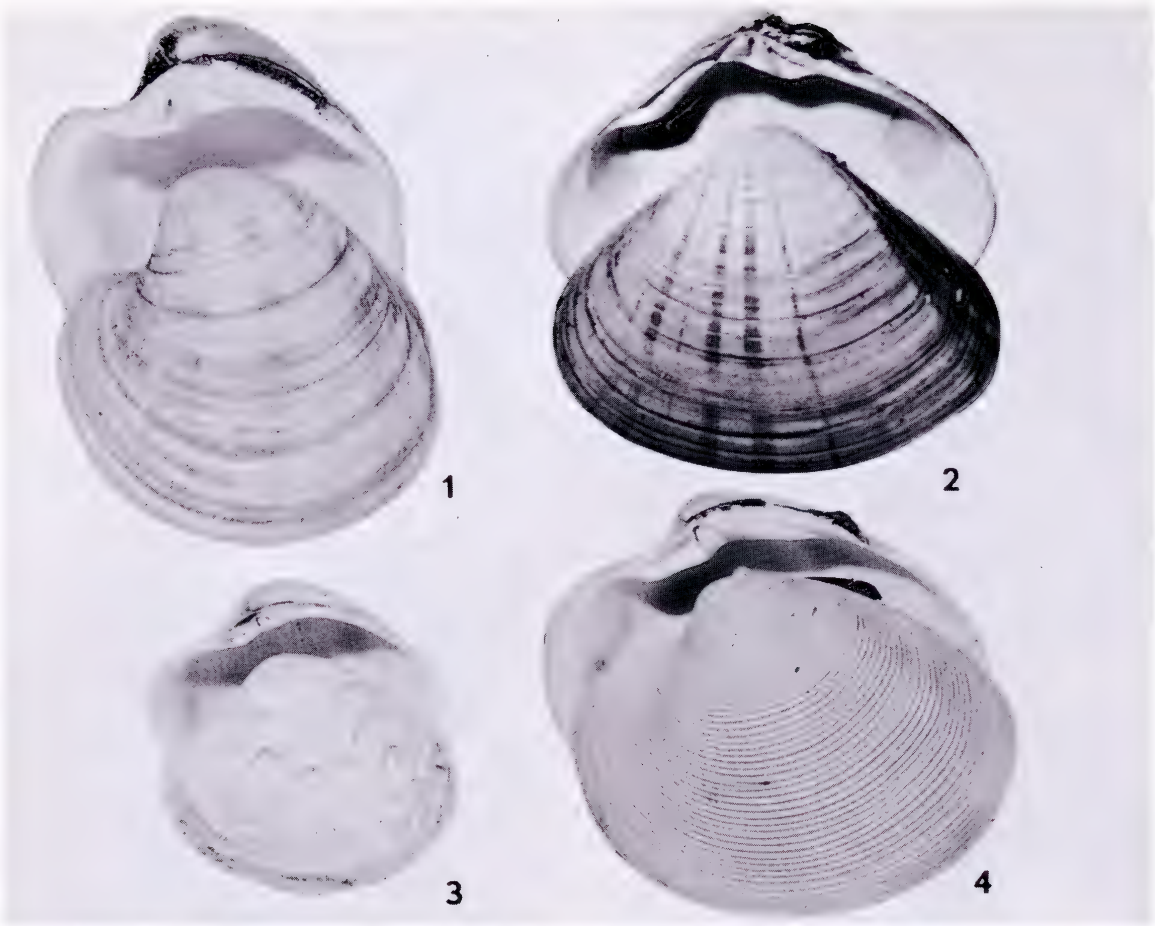

Figure 43. **1,** *Ventricolaria fordii,* x 1; **2,** *Tivela stultorum,* x 1; **3,** *Pitar newcombianus,* x 1; **4,** *Amiantis callosa,* x .7.

tric. A posterior sinus is present, indicative of siphons and a burrowing habit in the animal. A large family, represented by numerous genera and species. Many are valuable as food clams.

Ventricolaria Keen, 1954

Left valve with a small anterior lateral tooth, margin crenulate, sculpture primarily concentric, lunule deeply inset. One southern California species.

43.1 *Ventricolaria fordii* (Yates, 1890). Shell of moderate size, inflated. Sculpture of concentric undulations over fine concentric threading, and fine radial riblets. Color, buff, with radiating darker bands. Length, 40-60 mm. Fairly common in gravel beds adjacent to rocky areas under kelp, at depths of 30 feet or more. Range: Monterey Bay, California, to San Geronimo Island, northern Baja California.

Tivela Link, 1807

Triangular shaped clams with nearly central beaks, radiating hinge teeth, large cardinal teeth, anterior lateral of left valve prominent. Ligament short, elevated. The pallial sinus is shallow. Chiefly tropical in distribution, only one species occurs in California. They are shallow burrowers along exposed sandy beaches at low tide and just offshore.

43.2 *Tivela stultorum* (Mawe, 1823). Pismo Clam. Valves thick and heavy, nearly smooth, covered with an adherent varnish-like periostracum. Color buff, frequently with radiating bands of purple-brown. Length, 60-150 mm. Not uncommon at low tide and offshore to 30 feet along broad sandy beaches

exposed to strong surf. Range: Halfmoon Bay, California, to Magdalena Bay, Baja California.

Pitar Römer, 1857

A group having an anterior lateral tooth in the left valve, in addition to the three cardinal teeth. Medium sized shells, beaks anterior to center, smooth or with concentric sculpture, chiefly tropical.

43.3 *Pitar newcombianus* (Gabb, 1865). Shell inflated, smooth except for fine growth lines, lunule faintly marked. Color, whitish with a pattern of brown zigzag lines. Length, 30-45 mm. Loose valves are fairly common on coarse sand adjacent to kelp beds, 30 feet and deeper, particularly at Catalina Island. Range: Monterey, California, to southern Baja California.

Amiantis Carpenter, 1864

A single species in California.

43.4 *Amiantis callosa* (Conrad, 1837). WHITE AMIANTIS. Valves large, white, with glossy periostracum and strong concentric ribs that occasionally branch. Lunule is defined by a groove. Hinge area large, left valve with an anterior lateral tooth. Length, 50-100 mm. Fairly common below the low tide line along sandy beaches, to depths of 25 feet. Living specimens are often washed ashore after storms. Range: Santa Barbara, California, to southern Baja California.

Saxidomus Conrad, 1837

Thick shelled clams with a posterior gape, elongate ligament, no lunule or escutcheon, hinge teeth bifid, so that there appear to be 4-5 cardinal teeth in the right valve, 3-4 in the left valve, pallial sinus deep.

44.1 *Saxidomus nuttalli* Conrad, 1837. WASHINGTON CLAM. Thick shelled, with strong, raised concentric sculpture. Color, tan, interior white with purple staining at the posterior end. Juvenile shells, about 20 mm in length, are nearly smooth and have radiating bands of dark brown adjacent to the ligament and another in front of the beaks. Length, 60-100 mm. Common, buried deeply a foot or more in sandy areas of bays at low tide and in sand near rocky areas along the open coast. Range: Humboldt Bay, California, to San Geronimo Island, northern Baja California.

Chione Megerle von Mühlfeld, 1811

Medium sized shells, with concentric and radial sculpture, no anterior lateral tooth, margin finely crenulate, pallial sinus shallow. Shallow burrowers, found close to the surface. Primarily a tropical group, three species occur in southern California.

44.2 *Chione californiensis* (Broderip, 1835). CALIFORNIA CHIONE. Valves thick, heavy, sculptured with well-spaced raised concentric lamellae and flat radial ribbing. Lunule and escutcheon well marked, hinge area with purple-brown staining. Length, 40-55 mm. Not uncommon in sandy mudflat areas in bays and sloughs, close to the surface, also offshore, although less common than the other two species. Range: Carpinteria, California, to Panama.

44.3 *Chione undatella* (Sowerby, 1835). WAVY CHIONE. Similar to *C. californiensis*, but more elongate and with more closely spaced concentric lamellae. Lunule and escutcheon well defined. Length, 45-60 mm. Abundant in bays and lagoons, chiefly in sandy areas, also offshore. Range: Goleta, California, to Peru.

44.4 *Chione fluctifraga* (Sowerby, 1853). SMOOTH CHIONE. A thick shelled species with subdued sculpture, broad radial ribs, and closely spaced concentric sculpture. Differs from the other two species in lacking a definite lunule and escutcheon. Exterior whitish, hinge and posterior area with a purple-brown stain. Length, 50-60 mm. Fairly common on mud and sand flats in back bays. Range: Mugu Lagoon, California, to the Gulf of California.

Protothaca Dall, 1902

Littleneck clams have beaks well anterior to center, hinge with a bifid middle cardinal tooth, no lateral teeth, ligamental groove and ligament greatly elongate. Sculpture radial and concentric, lunule weakly marked, escutcheon absent. The pallial sinus is much deeper than that of the Chiones, extending

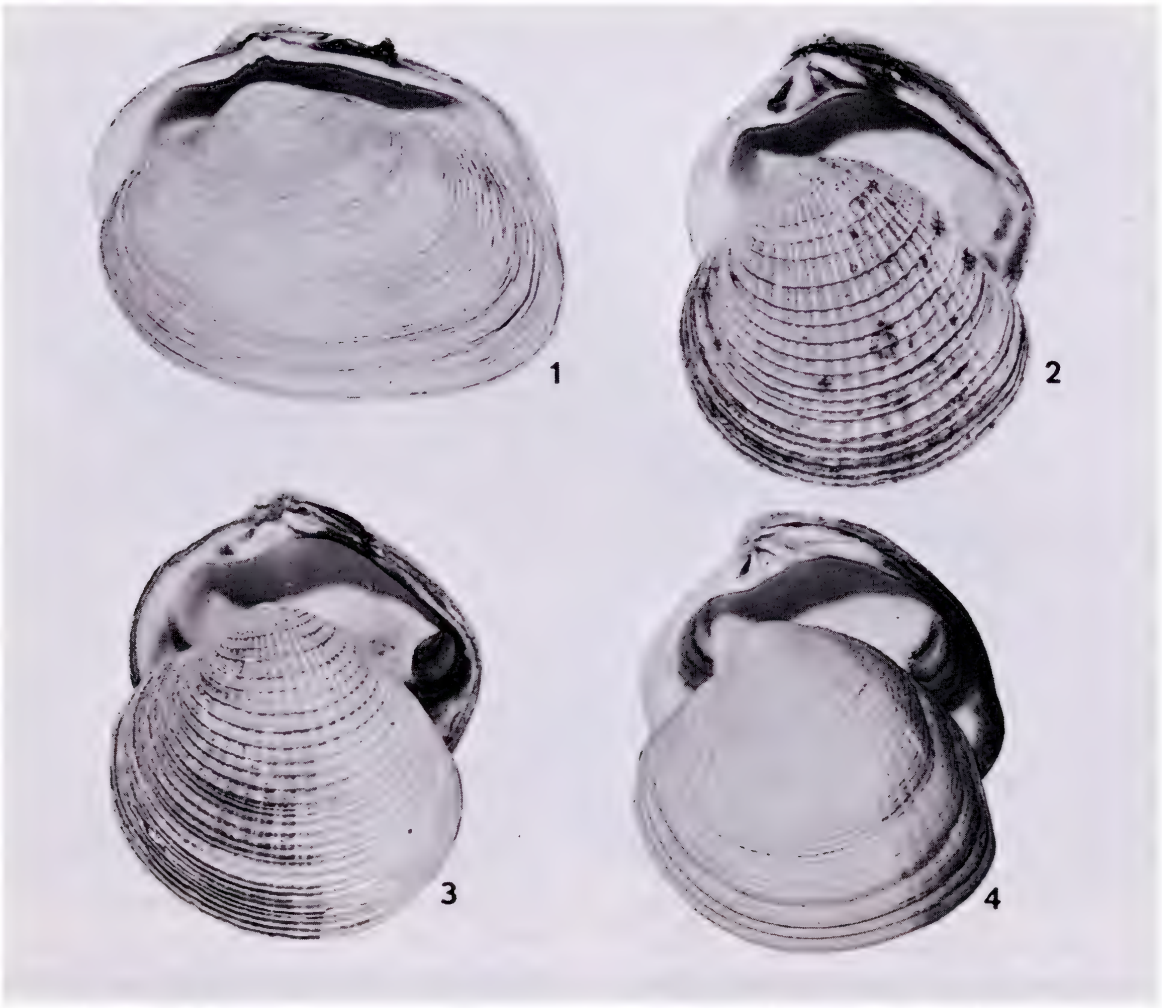

Figure 44. **1,** *Saxidomus nuttalli,* x .7; 2, *Chione californiensis,* x 1; **3,** *C. undatella,* x 1; **4,** *C. fluctifraga,* x 1.

forward about two-thirds the length of the pallial line. Three species occur in southern California.

45.1 *Protothaca staminea* (Conrad, 1837). COMMON LITTLENECK. Sculpture of broad radial ribs, strongest anteriorly, concentric sculpture weak. Color whitish or tan with flecking or zigzag markings of brown. Length, 40-60 mm. Abundant in sandy areas in bays and in coarse gravel under loose rocks along the open coast, middle to lower intertidal zones. Range: Aleutian Islands, Alaska, to southern Baja California.

45.2 *Protothaca laciniata* (Carpenter, 1864). ROUGH-SIDED LITTLENECK. Valves thick, inflated, with strong radial and concentric ribbing, raised intersections near the margin producing rough, rasp-like surface. Color, dark tan, interior white. Length, 50-80 mm. Not uncommon in sand or sandy mud in bays or in shallow water offshore, living several inches below the surface. Range: Monterey Bay, California, to Estero Todos Santos, northern Baja California.

45.3 *Protothaca tenerrima* (Carpenter, 1857). THIN-SHELLED LITTLENECK. Characterized by large, flattened, thin valves. Concentric sculpture is prominent while the radial sculpture is subdued. Color, whitish tan. Length, 65-110 mm. Burrows about one foot below the surface in sandy mud of bays and offshore along with *Saxidomus nuttalli,* with

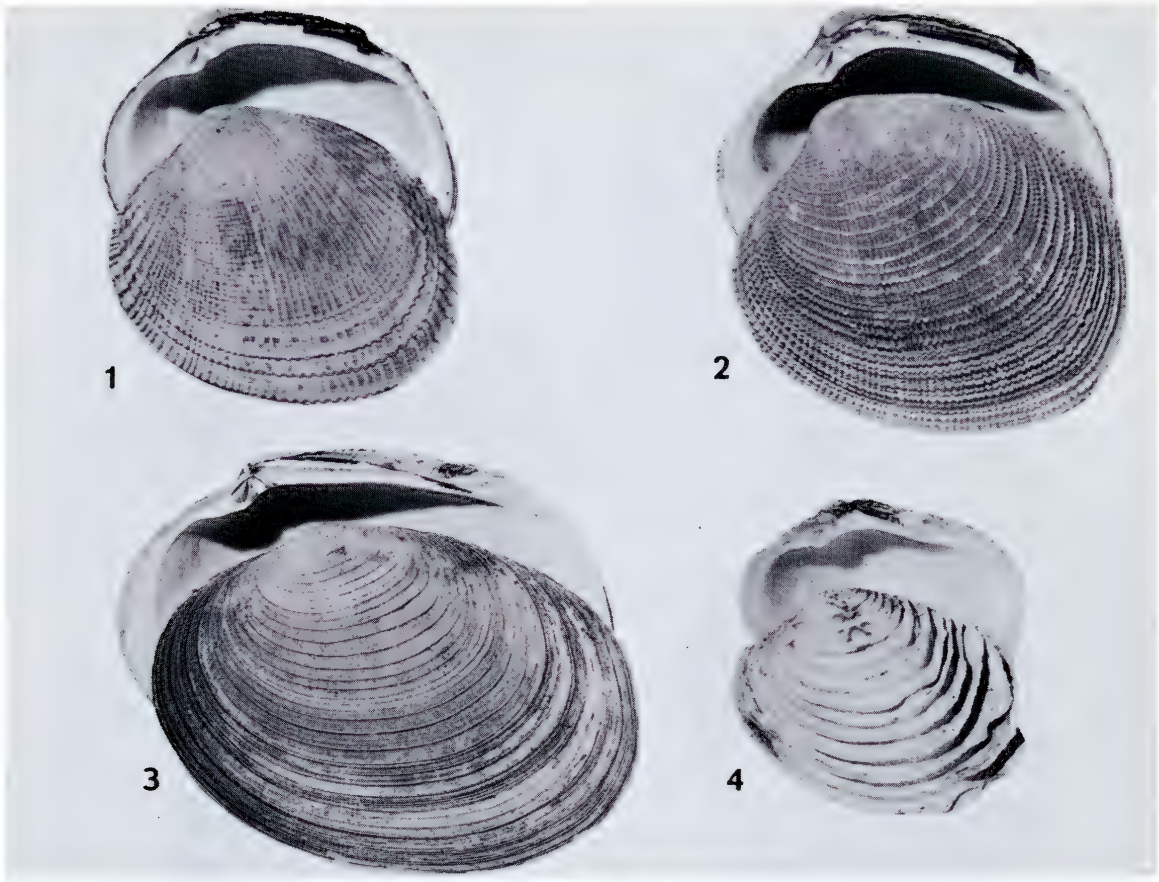

Figure 45. **1,** *Protothaca staminea*, x .7; **2,** *P. laciniata*, x .7; **3,** *P. tenerrima*, x .7; **4,** *Irus lamellifer*, x 1.

which it is often confused, although much less common. Range: Vancouver, British Columbia, to southern Baja California.

Irus Schmidt, 1818

Beaks anterior to center, outline nearly quadrate, lateral teeth absent, sculpture of strongly raised concentric lamellae and radial threads. Pallial sinus V-shaped. One species occurs in California.

45.4 *Irus lamellifer* (Conrad, 1837). Valves heavy, whitish, only rarely with brown chevron markings as illustrated, radial sculpture apparent only on the early stages, lunule narrow, bounded by an incised line. Length, 20-35 mm. Not uncommon, nestling in rock cavities and pholad holes, at low tide and in the sublittoral zone. Range: Monterey to San Diego, California.

Family PETRICOLIDAE

Nestling clams, often with irregular shells, an adaptation to fitting rock burrows. Lateral teeth, lunule, and escutcheon are absent. Left valve with three cardinal teeth, center often bifid, right valve with two projecting cardinal teeth, both usually bifid. Pallial sinus well developed.

Petricola Lamarck, 1801

Three species occur in Southern California.

46.1 *Petricola carditoides* (Conrad, 1837). Shell thick, outline irregular, quadrate or oval, surface chalky, with deep irregular growth lines. Juvenile shells show fine regular radial striae. Length, 20-40 mm. Fairly common in empty pholad holes in soft rock, intertidally and offshore. Range: Vancouver Island, British Columbia, to Magdalena Bay, Baja California.

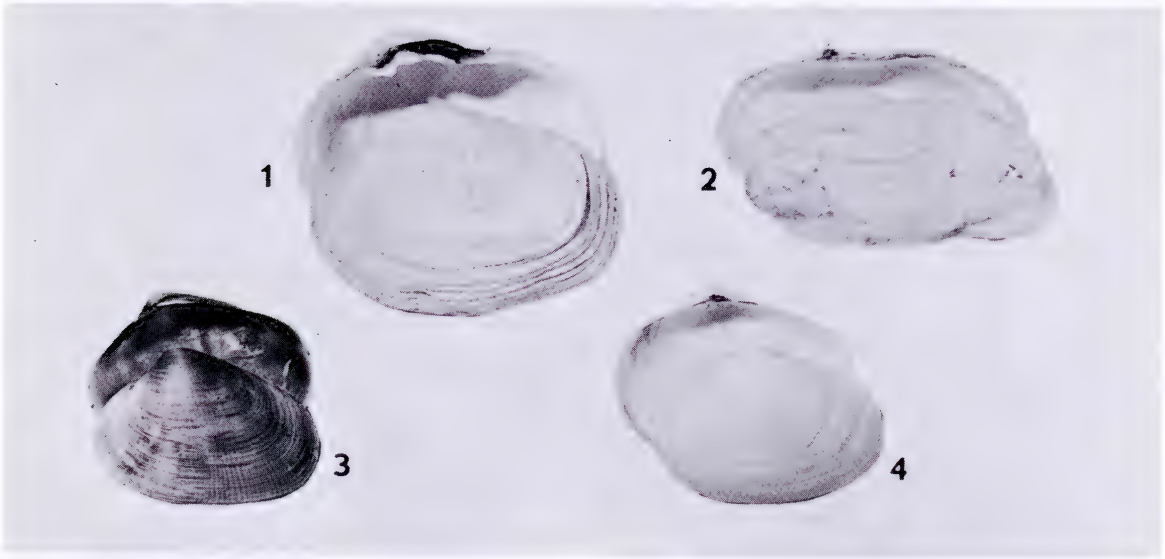

Figure 46. **1,** *Petricola carditoides*, x 1.5; **2,** *P. californiensis*, x 1.5; **3,** *P. tellimyalis*, x 4; **4,** *Cooperella subdiaphana*, x 3.

46.2 *Petricola californiensis* Pilsbry and Lowe, 1932. Thin shelled, irregular, elongate, both ends rounded. Radial sculpture of fine lines, more prominent anteriorly, concentric sculpture of growth irregularities. Pallial sinus deep, rounded. Color, white with purple brown stains on posterior hinge area and often across the dorsal posterior part of the shell. Length, 15-30 mm. Fairly common, nestling among *Mytilus* on floats or in pholad holes at low tide and in the sublittoral. Range: Playa del Rey, California, to San Ignacio Lagoon, central Baja California.

46.3 *Petricola tellimyalis* (Carpenter, 1864). A small thin shelled species of regular form showing fine radial striae. Color, purple-brown with radiating bands of yellow. Length, 6-11 mm. Common at times, nestling among *Mytilus*, bryozoa and algae, from low water to sublittoral depths. Range: Santa Monica, California, to San Martin Island, northern Baja California.

Family COOPERELLIDAE

Small burrowing clams with large pallial sinus, three cardinal teeth in the left valve and two in the right. All teeth are bifid.

Cooperella Carpenter, 1864

Small, thin shelled species. One species occurs in the eastern Pacific.

46.4 *Cooperella subdiaphana* (Carpenter, 1864). A small, thin whitish clam with beaks slightly in front of center, ligamental area short. The surface shows fine concentric growth lines. Length, 10-15 mm. A shallow burrower in muddy areas of bays and on offshore mud bottoms, fairly common. Range: Queen Charlotte Islands, British Columbia, to the Gulf of California.

Family MACTRIDAE

Deep burrowing clams of moderate to large size characterized by a large chondrophore or resilifer, a pit on the hinge for enclosure of the internal portion of the ligament. Relatively small A-shaped cardinal teeth are present just anterior to the chondrophore. Anterior and posterior lateral teeth are elongate. Shells are whitish and are covered with a fibrous periostracum.

Mactra Linnaeus, 1767

In addition to the internal ligament, there is a small external ligament separated from the chondrophore by a narrow shelf. Several

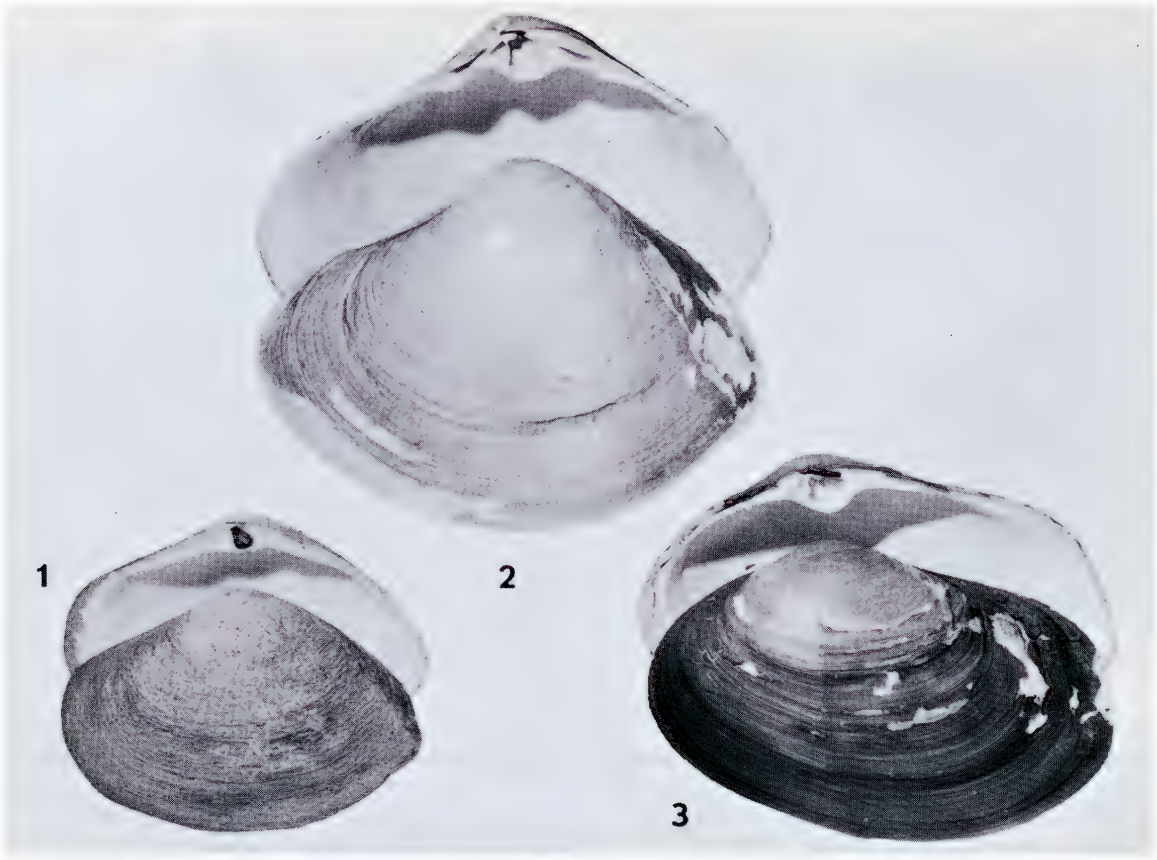

Figure 47. **1,** *Mactra californica,* x 1; **2,** *Spisula hemphilli,* x .5; **3,** *Tresus nuttallii,* x .7.

species occur in California, but only one is common.

47.1 *Mactra californica* Conrad, 1837. CALIFORNIA MACTRA. A relatively small, elongate species characterized by the fibrous periostracum in concentric rings, forming an angulate ridge along the dorsal posterior edge of the shell. The beaks have fine concentric undulations, not found in related forms. Length, 35-50 mm. Common on sand flats or sandy mud in bays and on offshore bottoms, buried at a depth of 3-6 inches. Range: Puget Sound, Washington, to Costa Rica.

Spisula Gray, 1837

Dish clams are larger than the Mactras and lack the shell lamella separating the small external ligament from the chondrophore.

47.2 *Spisula hemphilli* (Dall, 1894). HEMPHILL DISH CLAM. Relatively large, beaks central, anterior surface concave, lunule well marked. A posterior ridge extends dorsally from the beaks to the margin. Smooth except for growth lines. Shell buff colored under an adherent periostracum. Length, 90-130 mm. Rather uncommon in bays and protected areas along the open coast on fine sand or sandy mud, living at a depth of 6 or more inches. Range: Santa Barbara, California, to Ensenada, northern Baja California.

Tresus Gray, 1853

Shell large, oblong, beaks anterior to center, posterior end with a broad siphonal gape, cardinal and lateral teeth small, external ligament separated from the chondrophore by a ridge of shell. One species is common in southern California. *Schizothaerus* Conrad, 1853, is a synonym.

47.3 *Tresus nuttallii* (Conrad, 1837). GAPER. Large, with a yellowish shell and brown periostracum that flakes off readily. Incurrent and excurrent siphons are fused and not retractable into the shell. Length, 80-150

mm. Common on sandy bottoms at low tide in bays and on sheltered bottoms offshore, to depths of 100 feet. These clams burrow 1-3 feet beneath the surface and may be located by noting spouts of water ejected as the siphons retract. Range: Puget Sound, Washington, to Scammons Lagoon, central Baja California.

Family TELLINIDAE

Small to medium sized shells, rounded in front, angular and flexed posteriorly, the left valve tending to be more convex. Beaks nearly central, hinge with two small cardinal teeth in each valve and lateral teeth in some genera, the ligament external and relatively short. The pallial sinus is deep and wide, contacting the pallial line along most of the length. The tellens lie on one side, with the left valve down, a few inches below the surface on sandy or muddy bottoms. The posterior flexure or warping of the shell enables the two separate and flexible long siphons to extend to the sea floor. Their food consists of detrital material taken in through the inhalent siphon.

Tellina Linnaeus, 1758

Compressed, elongate shells, beaks slightly posterior to center. Shell surface glossy, white, or with red and pink coloration. Sculpture primarily of fine concentric striae.

48.1 *Tellina bodegensis* Hinds, 1845. Bodega Tellen. A cream colored elongate species of moderate size, the anterior end rounded, posterior end blunt. Surface glossy, with fine concentric striae and a thin periostracum, retained at the margin. Mature shells become thickened internally. Length, 45-55 mm. Occasionally common on sandflats in bays at low tide and on offshore sandy bottoms. Range: Queen Charlotte Islands, British Columbia, to southern Baja California.

48.2 *Tellina idae* Dall, 1891. Ida's Tellen. Of moderate size like *T. bodegensis*, this species is broader and has stronger concentric sculpture, forming raised lamellae along the posterior dorsal margin. The posterior end of the valves is flexed to the right and indented just in front of the posterior ridge. Length, 30-50 mm. Not uncommon offshore along sandy beaches to depths of 40 fathoms, occasionally washed ashore after storms. Range: Santa Barbara to San Diego, California.

48.3 *Tellina carpenteri* Dall, 1900. A rather small, elongate species with extremely fine concentric striae, characterized by its pink color, some specimens showing irregular white rays. Length, 10-12 mm. Occasionally common in sand or mud in bays and on offshore sandy bottoms. Range: Ketchican, Alaska, to Panama.

48.4 *Tellina modesta* (Carpenter, 1864). A small, white shelled species with the same sculpture and about the same proportion as *T. carpenteri*, but slightly larger. Internally there is a thickened ridge running between the anterior muscle scar and the forward extension of the pallial sinus. Length, 10-15 mm. Common offshore on sandy bottoms to depths of 35 fathoms, occasionally on sand bottoms at low tide in bays. Range: Alaska to San Bartolomé Bay, central Baja California. *Tellina buttoni* Dall, 1900, is a synonym.

Macoma Leach, 1819

Shell white with a flaky periostracum, rounded-trigonal in shape, only slightly inflated, relatively thin. Lateral teeth are absent.

48.5 *Macoma nasuta* (Conrad, 1837). Bent-Nose Macoma. Characterized by a marked posterior flexure. The ligament is longer than that of the other two species and the dorsal margin of the valves is not produced. The pallial sinus of the left valve reaches the anterior adductor, but that of the right does not. Length, 40-60 mm. Common in muddy areas of bays at low tide and on protected offshore mud bottoms. Range: Kodiak Island, Alaska, to southern Baja California.

48.6 *Macoma indentata* Carpenter, 1864. Indented Macoma. Shell glossy white with a very thin periostracum. The ligament is short and the margin of the valves behind it is produced. The posterior end is flexed and the ventral margin of the valves is indented. Length, 40-50 mm. Common at times in bays at low tide and offshore on sandy bottoms.

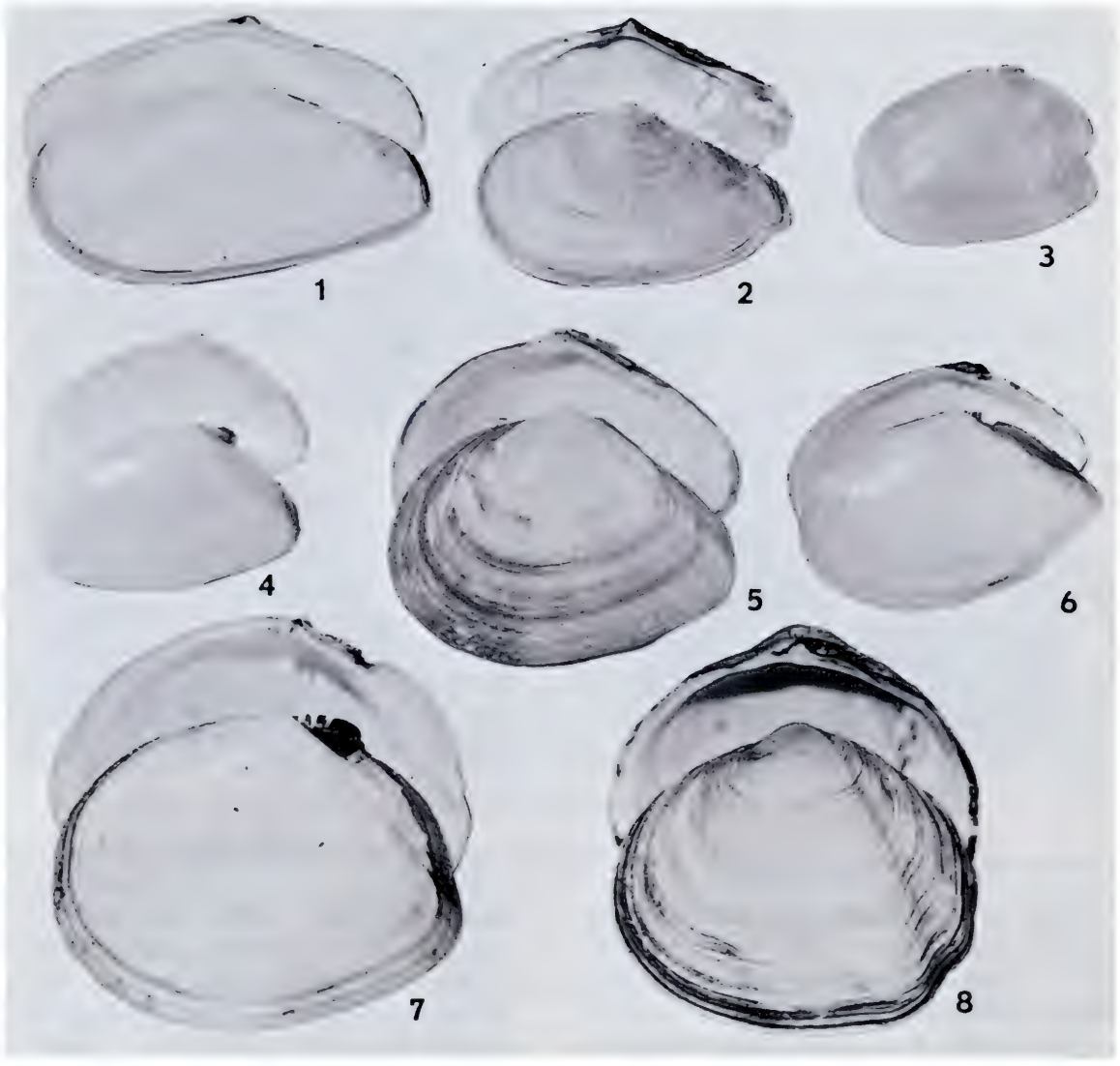

Figure 48. **1,** *Tellina bodegensis,* x 1; **2,** *T. idae,* x 1; **3,** *T. carpenteri,* x 3; **4,** *T. modesta,* x 2; **5,** *Macoma nasuta,* x 1; **6,** *M. identata,* x 1; **7,** *M. secta,* x .7; **8,** *Florimetis obesa,* x .7.

Range: Puget Sound, Washington, to southern Baja California.

48.7 *Macoma secta* (Conrad, 1837). WHITE MACOMA. A relatively large white shelled species with a thin, olive colored periostracum. Like *M. indentata* it has a short bulbous ligament and a produced margin of the valves behind the ligament. However, it is larger and higher and lacks the indentation. Length, 70-90 mm. Not uncommon in sandy areas near bay entrances and off sandy beaches beyond the surf zone. Range: Vancouver Island, British Columbia, to southern Baja California.

Florimetis Olsson and Harbison, 1953

Moderately inflated shells, strongly flexed, external ligament set in a deep pit, lateral teeth absent. Listed as *Apolymetis* in older works. One species occurs in southern California.

48.8 *Florimetis obesa* (Deshayes, 1855). Shell of moderate to large size, characterized by two angular ridges and grooves setting off

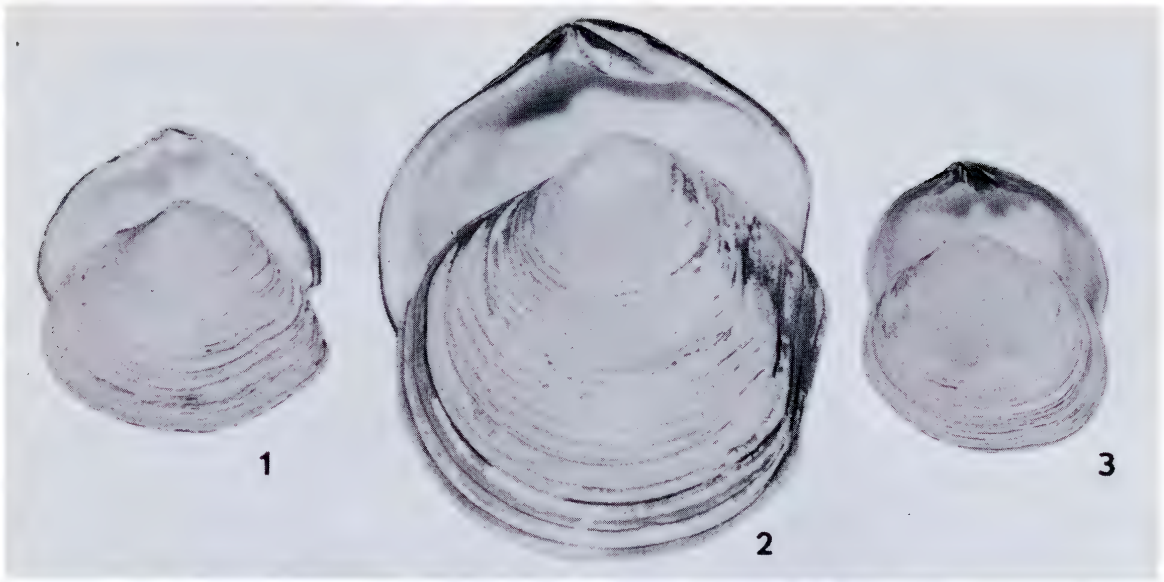

Figure 49. **1,** *Cumingia californica*, x 1; **2,** *Semele decisa*, x .7; **3,** *S. rupicola*, x 1.

the posterior slope. Sculpture consists of well-marked growth increments. Color, yellowish white with a brown periostracum worn away except at the margins, interior yellowish. Length, 40-70 mm. Small specimens are common in sand and gravel areas in bays, larger specimens occur offshore. Range: Point Conception, California, to Magdalena Bay, Baja California. Synonym, *F. biangulata* (Carpenter).

Family SEMELIDAE

Solid shells, of medium to large size, beaks nearly central, smooth or concentrically sculptured. The two cardinal teeth in each valve are small, but anterior and posterior laterals are large. The most distinctive feature is the large internal ligament contained in a backward slanting resilifer directly behind the cardinal teeth. There is also a relatively small external ligament. The pallial sinus is deep and broader behind the entrance, its end rounded.

Cumingia Sowerby, 1833

Trigonal white shells sculptured with concentric lamellae, hinge with a short, triangular resilifer. The lateral teeth are large in the right valve, nearly lacking in the left. Base of the pallial line continuous with the pallial sinus. One species occurs in California.

49.1 *Cumingia californica* Conrad, 1837. Thick shelled, with irregular concentric lamellae, often stunted or distorted as a result of nestling in cramped spaces. Length, 20-32 mm. Common in rock crevices and gravel near rocks, from low tide to sublittoral depths. Range: Mendocino County, California, to southern Baja California.

Semele Schumacher, 1817

Generally rounded or ovate shells with an elongate resilifer, and an upward directed pallial sinus not continuous with the pallial line. Lateral teeth are strong in both valves. Red, yellow, and purple colors occur in this genus.

49.2 *Semele decisa* (Conrad, 1837). CLIPPED SEMELE. A stout, thick shelled species characterized by deep concentric grooves except on the early growth stage, a fine pustulose surface, and remnants of a thick periostracum in the grooves near the margin. Exterior whitish, interior with a purple tinge around the margins and at the hinge. Length, 60-90 mm. Fairly common in coarse gravel near rocky areas along the exposed coast, from low tide to shallow sublittoral depths. Live specimens may be difficult to find, but fresh valves are frequent. Range: Santa Barbara, California, to Cape San Lucas, Baja California.

49.3 *Semele rupicola* Dall, 1915. A relatively small species with beaks forward of center, having fine, irregular concentric lamellae, a relatively short resilifer, and a red-orange hinge and interior margin. The shell is often distorted, a result of its nestling habit. Length, 20-45 mm. Fairly common, nestling in crevices and in mussel beds at low tide and in shallow sublittoral zones. Range: Monterey, California, to Cape San Lucas, Baja California.

Family DONACIDAE

Relatively small shells, trigonal in shape, hinge with two cardinal teeth and one or more lateral teeth on each side, ligament external.

Donax Linnaeus, 1758

Beaks posterior to center, ligament short, margins of the valves crenulate, reflecting external ribbing. Living *Donax* occur on sandy beaches or in bays, burrowing close to the surface. They move rapidly and are able to rebury quickly if dislodged by surf. There are numerous tropical species but only two in California.

50.1 *Donax californicus* (Conrad, 1837). WEDGE CLAM. An elongate species with fine radial striae covered with a glossy, varnish-like dark yellow periostracum. Interior white, with some purple staining along the hinge. Length, 15-25 mm. Common at times in sandy areas of bays or protected open areas at low tide. Range: Santa Barbara, California, to Magdalena Bay, southern Baja California.

50.2 *Donax gouldii* Dall, 1921. BEAN CLAM. Beaks close to the posterior end of the shell. A ridge extends diagonally from the beaks and sets off a flattened posterior area. Radial sculpture low but producing strong crenulation at the margin, concentric growth lines clearly marked. Color, variable, usually cream, often with buff rays. Length, 15-21 mm. Abundant in some years on exposed sandy beaches along the open coast. Frequently found with hydroid colonies attached to the posterior end. Range: Santa Cruz County, California, to southern Baja California, sporadic north of Point Conception.

Family PSAMMOBIIDAE

Sunset clams have beaks nearly central or just forward of center, hinge dentition consisting of two small, sometimes bifid cardinal teeth in each valve, no lateral teeth. Ligament external, short and bulbous, attached to a thickened projecting platform behind the beaks. They are relatively deep burrowers, as indicated by the broad pallial sinus.

Gari Schumacher, 1817

Characterized principally by a narrow but definite posterior gape. The cardinal teeth are not bifid and the ligamental platform is well developed. Siphons are long and separate.

50.3 *Gari californica* (Conrad, 1849). SUNSET CLAM. A yellow-white clam with radiating bands of pink, smooth except for fine irregular growth lines, with a thin brown periostracum mostly worn away except at the margins of the shell. Interior glossy white. Length, 50-100 mm. Common in sand and gravel near rocky areas along the open coast, at low tide and in the sublittoral, also in sandflats at bay entrances, living specimens being seldom seen, although empty valves are common. Range: Shelikof Strait, Alaska, to Magdalena Bay, Baja California.

Heterodonax Mörch, 1853

Relatively small shells, trigonal in shape, margins of the valves fitting tightly. The ligamental platform is present, but the ligament is smaller than in other genera. One species occurs in California.

50.4 *Heterodonax pacificus* (Conrad, 1837). Shell solid, smooth except for fine growth lines, surface glossy, with a thin yellow periostracum. Color highly variable, white, yellow, pink or brown, some with interrupted brown or gray rays. Length, 21-26 mm. Common on sandy shores of bays, close to the high tide line, burrowing near the surface. Range: Point Conception, California, to northern Peru. Previously known as *H. bimaculatus* (Linnaeus), a species now considered to be restricted to the Caribbean province.

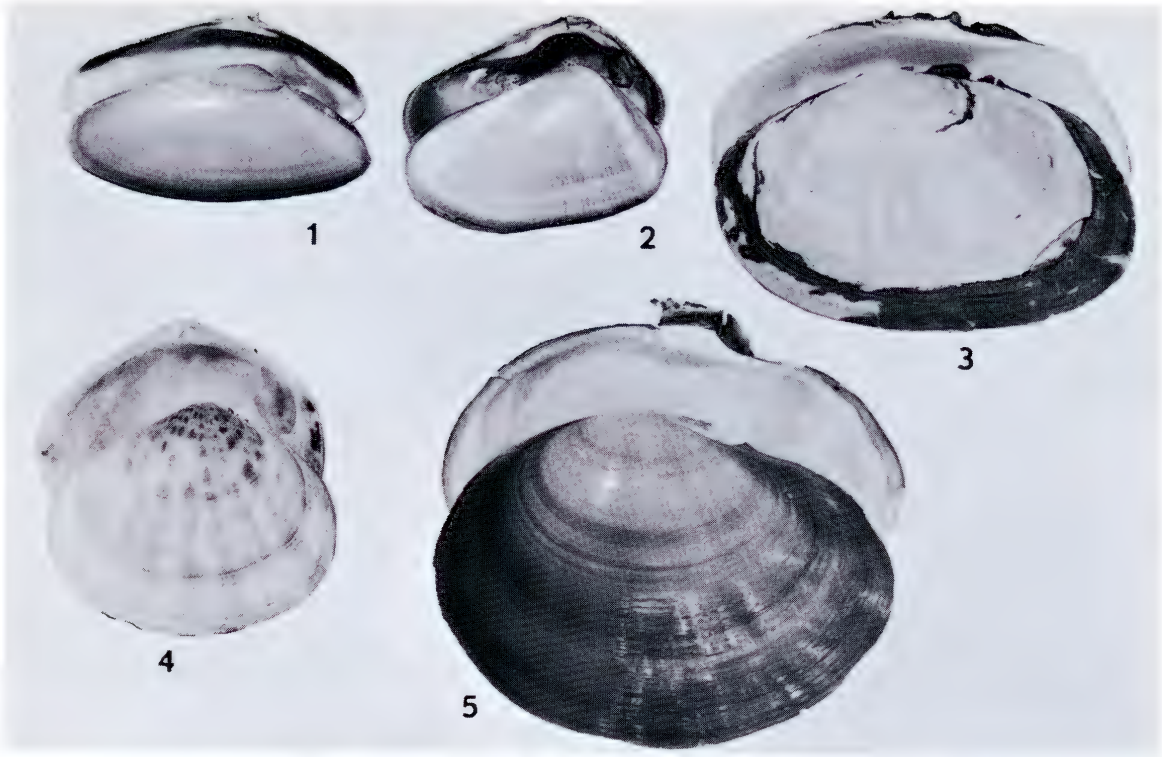

Figure 50. **1,** *Donax californicus*, x 1.5; **2,** *D. gouldii*, x 1.5; **3,** *Gari californica*, x .7; **4,** *Heterodonax pacificus*, x 1.5; **5,** *Sanguinolaria nuttallii*, x .7.

Sanguinolaria Lamarck, 1799

Moderately sized, thin, smooth, gaping, the right valve flatter than the left, anterior cardinal tooth of left and posterior of right valve bifid, ligament large, projecting. One species occurs in California.

50.5 *Sanguinolaria nuttallii* (Conrad, 1837). PURPLE CLAM. Valves large, right valve nearly flat, left valve convex. Color, gray-white with weak purple rays, shell surface covered with a closely adherent, varnish-like periostracum, darkest at the margins, interior purple. Length, 60-90 mm. Fairly common at low tide in bays in sand and gravel areas, buried at about 12 inches. Range: Bodega Bay, California, to Magdalena Bay, Baja California.

Tagelus Gray, 1847

Jackknife clams have the dorsal and ventral margins nearly parallel. They form permanent burrows in which they are able to move rapidly up and down.

51.1 *Tagelus californianus* (Conrad, 1837). CALIFORNIA JACKKNIFE CLAM. A relatively large whitish form with a thick brown periostracum, worn away except at the edges of the valves. Superficial, dark stained cracks in the valves perpendicular to the long axis appear to give it a color pattern. Length, 60-100 mm. Common on sandy mudflats of bays, in permanent burrows extending 4-20 inches deep. Range: Humboldt Bay, California, to Panama.

51.2 *Tagelus subteres* (Conrad, 1837). Smaller than *T. californianus*, the periostracum differs in being glossy, except in the posterior area where it is thick and lamellar. The whitish shell shows violet rays and interior staining of violet. Length, 45-50 mm. Common in bays on sand and mudflats at low tide. Range: Morro Bay, California, to San Ignacio Lagoon, central Baja California.

Family SOLENIDAE

Razor clams with beaks at or near the anterior end, valves broadly gaping at both ends.

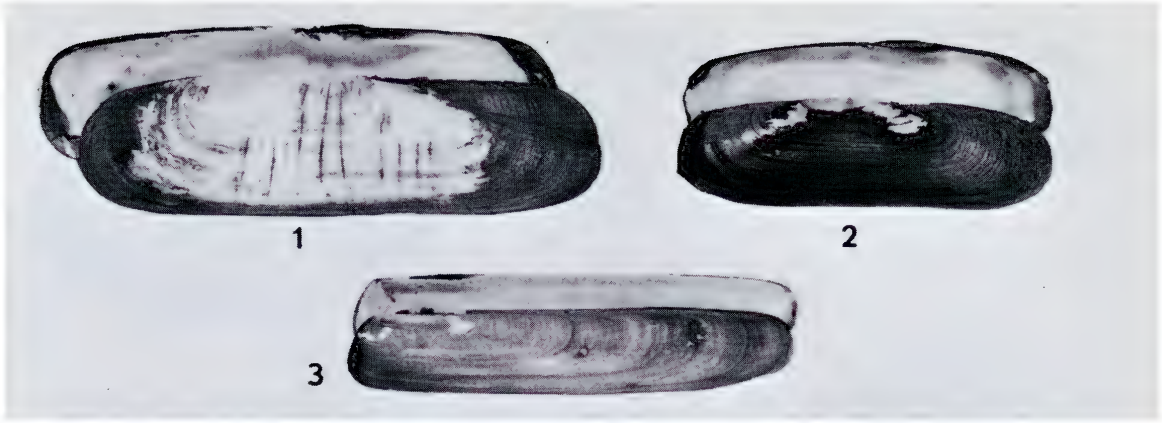

Figure 51. **1,** *Tagelus californianus*, x .7; **2,** *T. subteres*, x 1; **3,** *Solen rosaceus*, x 1.

Dentition consists of one or two peg-like cardinal teeth.

Solen Linnaeus, 1758

Elongate tubular shells with beaks at the anterior end, a single cardinal tooth in each valve. The anterior end is cut off squarely or slightly rounded.

51.3 *Solen rosaceus* Carpenter, 1864. Rosy Razor Clam. Shell thin, fragile, anterior end bluntly rounded, posterior end tapered and rounded. Shell gray-white, with a rose tint at the beaks, covered with a glossy periostracum. Length, 60-75 mm. Fairly common in sandy areas of bays at low tide, in permanent burrows well below the surface. Range: Santa Barbara, California, to Mazatlan, Mexico.

Family MYIDAE

Valves lacking true dentition or a hinge plate, left valve with a projecting spoon shaped chondrophore, an attachment structure for the internal ligament. Right valve more convex, with a deep pit for ligamental attachment in the umbonal cavity. These are white shelled species with chalky textures and thick periostracum. Illustrations of the following two species show the interior of the left valve rather than the right, to show the chondrophore.

Cryptomya Conrad, 1848

Differs from the more northern genus *Mya* in lacking a pallial sinus. Only one west American species.

52.1 *Cryptomya californica* (Conrad, 1837). A relatively small species with a thin, brown periostracum, smooth except for fine concentric sculpture. Valves with a slight posterior gape and only a slight indication of a pallial sinus, chondrophore of left valve prominent. Length, 25-30 mm. Common in sand and sandy mud of bays from the midtide level to the sublittoral along the open coast. A shallow burrower, with short siphons, but may be deeply buried, its siphons in contact with the deep burrows of ghost shrimps or *Urechis* worms. Range: Gulf of Alaska to northern Peru.

Platyodon Conrad, 1837

A genus with a single west American species closely related to *Mya*, but having a shorter, less prominent chondrophore and regular concentric sculpture. The pallial sinus is deep and rounded.

52.2 *Platyodon cancellatus* (Conrad, 1837). A medium sized species with beaks posterior to center, anterior end rounded, posterior end truncate and widely gaping. Sculpture of regular concentric lamellae, periostracum thick at the margins and near the posterior end of the shell. Length, 45-70 mm. Fairly common, burrowing in hard packed clay or soft sandstone, adjacent to pholad burrows, at protected areas along the open coast. Range: Queen Charlotte Islands, British Columbia, to San Diego, California.

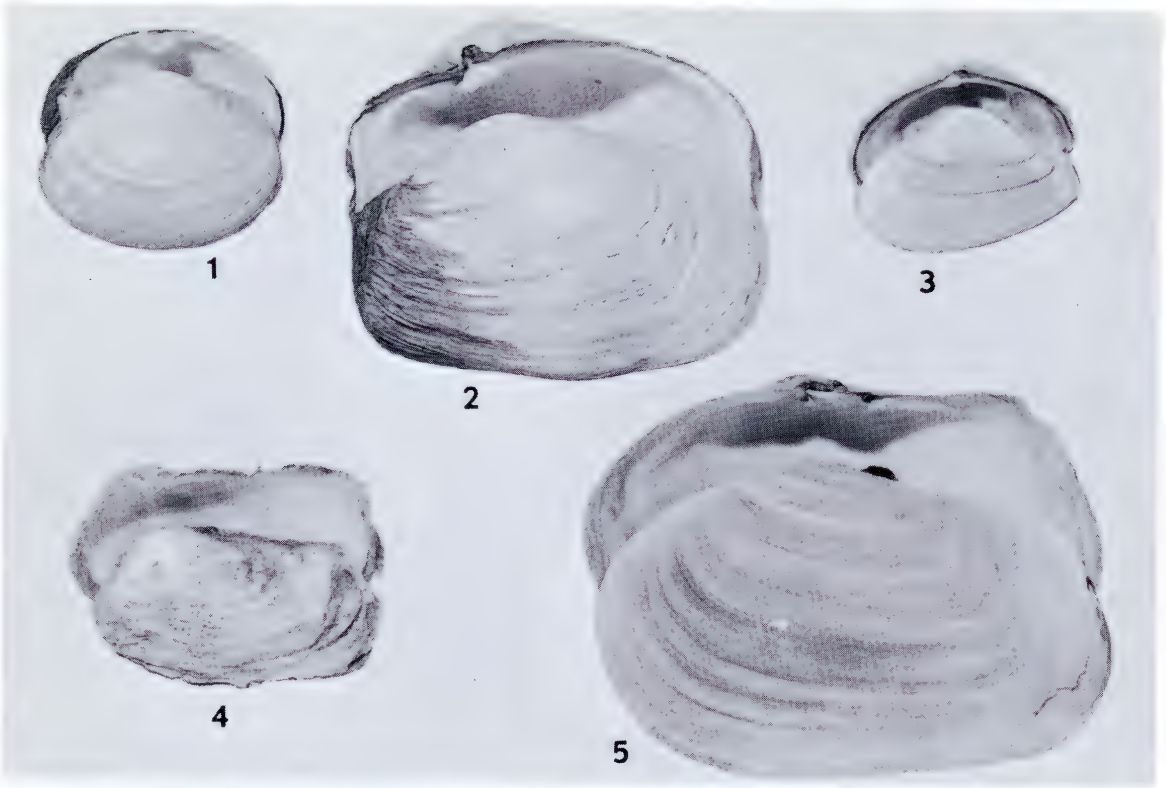

Figure 52. **1,** *Cryptomya californica*, x 1; **2,** *Platyodon cancellatus*, x 1; **3,** *Corbula luteola*, x 3; **4,** *Hiatella arctica*, x 2; **5,** *Panopea generosa*, x .7.

Family CORBULIDAE

Small shells, right valve larger and more convex, left valve fitting into the right at the margins, no gape. Ligament internal, short, a flat-surfaced chondrophore in left valve projecting into a corresponding depression in right valve. A cardinal tooth-like structure in the right valve projects into a depression in front of the chondrophore of the left. Superficially there appears to be a single cardinal tooth in each valve. Pallial sinus lacking.

Corbula Bruguière, 1797

Sculpture consisting of concentric ridges. Primarily a tropical group, one species ranging into southern California.

52.3 *Corbula luteola* Carpenter, 1864. A small species, the right valve only slightly larger than the left, with regular concentric sculpture, usually showing darker growth stages. Posterior slope defined by a keel, the posterior end slightly truncate. Color, yellow to gray, occasionally pink, interior pink around the hinge and muscle scar. Length, 7-10 mm. Common at some localities, scarce at others, attached by byssus in rocky rubble at low tide and in sublittoral zones. Range: Monterey, California, to the Gulf of California.

Family HIATELLIDAE

Beaks toward the front end of the shell, ligament external, hinge line with a projecting cardinal tooth in the right valve fitting into a pit in the left valve. Sculpture concentric. Pallial sinus present but pallial line sometimes broken into a series of separate scars.

Hiatella Bosc, 1801

Small nestling clams of irregular shape, gaping at the posterior end, dentition nearly worn in large specimens.

52.4 *Hiatella arctica* (Linnaeus, 1767). Quadrate in shape, beaks near the front margin, a ridge running diagonally downward from the beaks, sculpture of irregular con-

centric ridges. Color, chalky white, with yellowish periostracum. Length, 15-25 mm. Common, nestling in pholad holes, crevices and kelp holdfasts, from low tide to sublittoral zones. Range: Arctic Ocean to Panama.

Panopea Ménard, 1807

Relatively large shells, valves gaping on all sides except at the hinge, one projecting cardinal tooth in each valve, ligament external, short, attached to a thickened ridge, pallial line and sinus demarked by a relatively broad scar area.

52.5 *Panopea generosa* (Gould, 1850). GEODUCK. Shell relatively large, whitish with a thin, light colored periostracum. Anterior end rounded, posterior end truncate, sculpture consisting of irregular growth undulations. The siphons are joined, forming a tube that cannot be retracted within the shell, constituting half the weight of the living clam. Length, 100-180 mm. Living in sandy mud of bays, at a depth of several feet, the siphons extending to the surface. Not common in southern California but occasionally found at San Pedro. Range: Forrester Island, Alaska, to Scammons Lagoon, central Baja California.

Family PHOLADIDAE

Pholads or piddocks are clams that bore into relatively hard substrates, compacted mud, soft rock, wood or other shells. This is accomplished chiefly by mechanical means. The foot of growing, active clams projects through an anterior gape. Contraction and rotation of the foot brings the roughened ridges on the anterior slope of the valves into contact with the substrate and the burrow is enlarged by a filing action. Feeding goes on in the usual bivalve manner. In some forms the boring ceases as the shell reaches maturity and the anterior opening where the foot projects is sealed over with a smooth shelly extension of the valve known as the callum. Both valves are nearly equal in size. True hinge teeth are absent. The apophysis, a structure for muscular attachment, projects internally beneath the hinge. The valves do not close tightly together along the dorsal and ventral margins. Accessory shelly plates, which seal over these areas, have developed in some genera.

Barnea Risso, 1826

Pholads with only a single dorsal supplementary plate, the protoplax, covering the area anterior to the umbones. Valves gaping anteriorly at all stages. Relatively thin shelled, they bore chiefly in compacted mud. One eastern Pacific species.

53.1 *Barnea subtruncata* (Sowerby, 1834). MUD PIDDOCK. Valves nearly cylindrical in shape, white with a thin brown periostracum. Sculpture of raised concentric and radial ridges, strong on the anterior end but fading until nearly smooth at the posterior end. Siphons long, not retractable. Length, 50-70 mm. Not common, living at depths of 10 inches in the stiff mud of bays at low tide. Range: Newport, Oregon, to Chile. *Barnea pacifica* (Stearns) is a synonym.

Zirfaea Gray, 1842

Characterized by a single dorsal plate, the mesoplax, a small triangular shaped plate posterior to the umbones. Shell broadly gaping at both ends, apophyses broad, spoon shaped.

53.2 *Zirfaea pilsbryi* Lowe, 1931. ROUGH PIDDOCK. Valves sturdy, dirty white, anterior end with coarse concentric sculpture and spiny radial points with a file-like surface. Posterior area of shell smooth except for growth lines, set off from anterior area by a groove running from the umbones to the ventral margin. Siphons not retractable. Length, 60-120 mm. Burrowing at depths to 14 inches in heavy mud of bays. Range: Nunivak Island, Alaska, to Magdalena Bay, Baja California.

Chaceia Turner, 1955

Valves large, oval, inflated, gaping anteriorly and posteriorly, accessory plate consisting only of a small triangular mesoplax as in *Zirfaea.* The anterior gape is partially closed by the callum in mature specimens. The valves are in contact on the ventral surface only at the terminus of the dorsal ventral groove separating the rough anterior sculpture from the

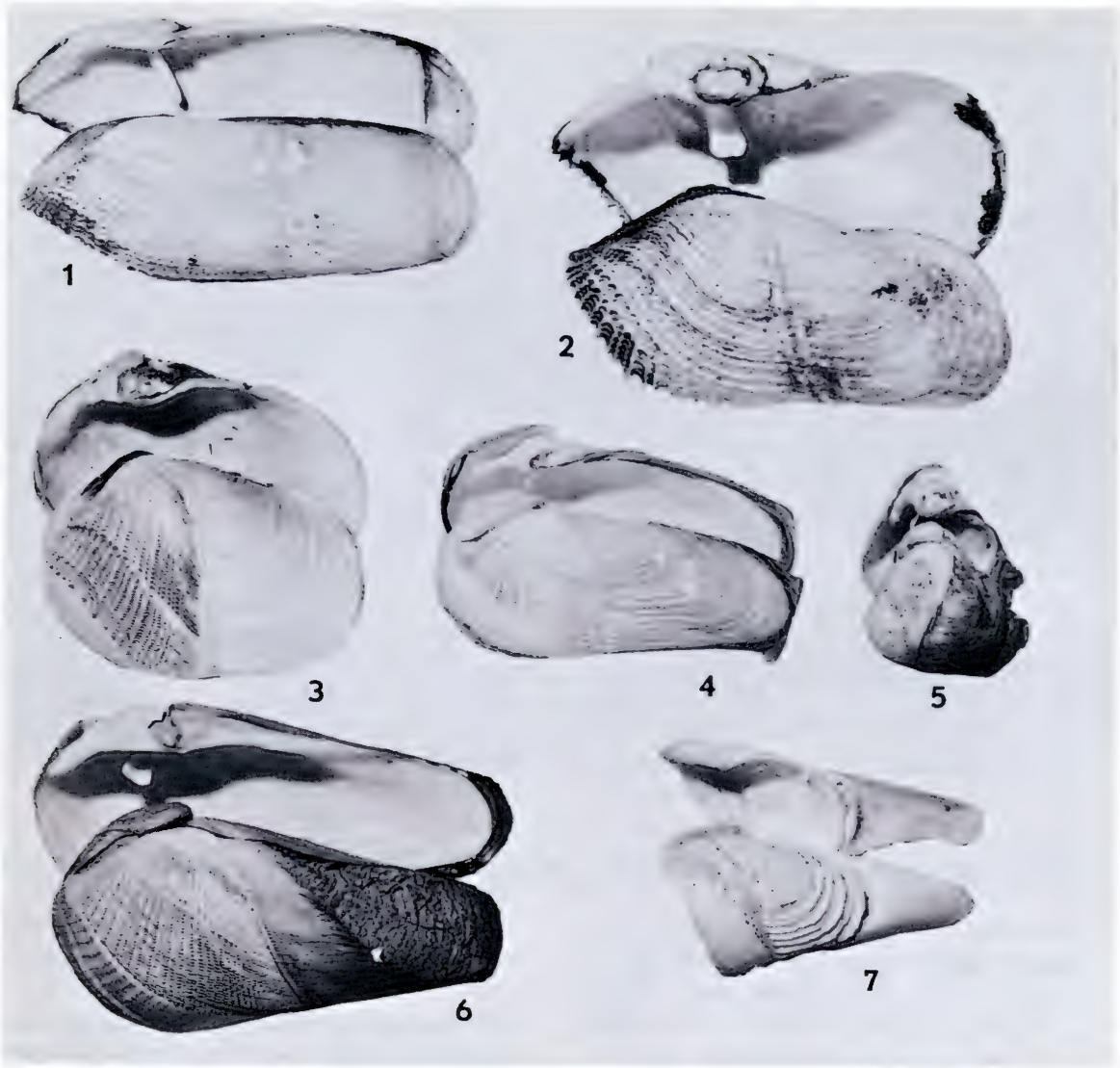

Figure 53. **1,** *Barnea subtruncata*, x 1; **2,** *Zirfaea pilsbryi*, x .7; **3,** *Chaceia ovoidea*, x .7; **4,** *Penitella penita*, x 1; **5,** *P. conradi*, x 2; **6,** *Parapholas californica*, x .7; **7,** *Netastoma rostrata*, x 2.

concentric ridges of the posterior area. A monotypic genus.

53.3 *Chaceia ovoidea* (Gould, 1851). WART-NECKED PIDDOCK. A relatively large species with grayish white valves. The siphons cannot be retracted and are light colored with dark wart-like lumps. Length, 60-90 mm. Not common, boring in shale and soft rocks at low tide. Range: Santa Cruz, California, to San Bartolomé Bay, central Baja California.

Penitella Valenciennes, 1846

Valves divided into two regions of different sculpture, mature specimens with a callum covering the anterior gape and extending to cover the area just in front of the beaks. The dorsal accessory plate is the mesoplax posterior to the umbones as in *Zirfaea*. Not gaping posteriorly, siphons retractable within the shell. In some species the siphons secrete a fibrous or weakly calcified posterior extension of the shell, the siphonoplax.

53.4 *Penitella penita* (Conrad, 1837). FLAP-TIPPED PIDDOCK. Medium sized, the anterior region with rough sculpture, the posterior area with a brown periostracum in fi-

brous concentric ridges, mesoplax sharply pointed posteriorly, siphonoplax consisting of leathery extensions at the posterior end that curl outward in dried specimens. Length, 40-70 mm. The most abundant piddock, found boring in nearly all soft rocks exposed at low tides and in sublittoral depths. Range: Bering Sea, Alaska, south to San Bartolomé Bay, central Baja California.

53.5 *Penitella conradi* Valenciennes, 1846. Abalone Piddock. A relatively small, compressed species differing chiefly from *P. penita* in size, in having the posterior end of mesoplax oval, and a slightly calcified siphonoplax. Length, approximately 10 mm. Specimens usually bore into abalone or other shells, only rarely in soft rocks. Living abalones form blister pearls, internal lumps in the shells, around the burrows. Range: Mendocino County, California, to San Bartolomé Bay, central Baja California.

Parapholas Conrad, 1848

Callum producing pholads characterized by division of the valves into three differently sculptured areas and by the large number of accessory plates, the dorsal mesoplax over the umbones, the dorsal metaplax posterior to the umbones, and the ventral hypoplax. The metaplax and the hypoplax are elongate structures that seal the mature shell. As in *Penitella*, the callum extends dorsally to the beaks. The siphonoplax is absent, but the siphons secrete a chimney, a tube of fine cemented particles separate from the shell.

53.6 *Parapholas californica* (Conrad, 1837). Scale-Sided Piddock. Relatively large and easily recognized by the overlapping layers of coarse brown periostracum on the posterior third of the valves. Mature specimens are sealed on all sides by the accessory plates, except for the siphonal opening. Length, 50-100 mm. Fairly common, associated with *Penitella penita*, in soft rocks at low tide and in sublittoral depths. Range: Bodega Bay, California, to San Bartolomé Bay, central Baja California.

Netastoma Carpenter, 1864

Relatively small pholads characterized by a long calcareous siphonoplax in mature specimens and by an incomplete callum anteriorly; apophyses and accessory plates absent. *Nettastomella* is an invalid replacement name.

53.7 *Netastoma rostrata* (Valenciennes, 1846). Beaked Piddock. Small delicate shells, the anterior widely gaping and bordered by a narrow callum area with thin wavy ridges, posterior area with concentric ridges. The siphonoplax is elongate and may be bent to fit the burrow. Length, 15-20 mm. Fairly common with the other pholads in soft rock, at low tide and in sublittoral depths. Range: British Columbia to Cedros Island, central Baja California.

Family LYONSIIDAE

Small, thin, white shells of irregular shape, beaks forward of center. Cardinal teeth are absent, and the ligament is internal, set in a trough and attached to the ossicle, an elongate white calcareous body connecting the two valves. Pallial sinus shallow. Traces of thin nacre are found in the valves.

Lyonsia Turton, 1822

Elongate clams with a truncate posterior end, having fine radial sculpture. Sand grains adhere to ridges of periostracum, especially at the edges of the valves.

54.1 *Lyonsia californica* Conrad, 1837. California Lyonsia. A small white species, inflated about the beaks, surface opalescent. Length, 15-25 mm. Fairly common, just beneath the surface on mud bottoms of bays at low tide and offshore. Range: Sitka, Alaska, to Manuela Lagoon, central Baja California.

Mytilimeria Conrad, 1837

A monotypic genus.

54.2 *Mytilimeria nuttalli* Conrad, 1837. The fragile shell is oval and inflated, white with a light brown periostracum. A slight sheen of nacre shows in the interior, pallial sinus shallow, ossicle conspicuous. Length, 25-40 mm. Common, embedded in compound tunicates, at low tide and in the sublittoral. The living clams may be hard to detect with only the siphons showing, but dead specimens with gaping valves are often seen on the sides

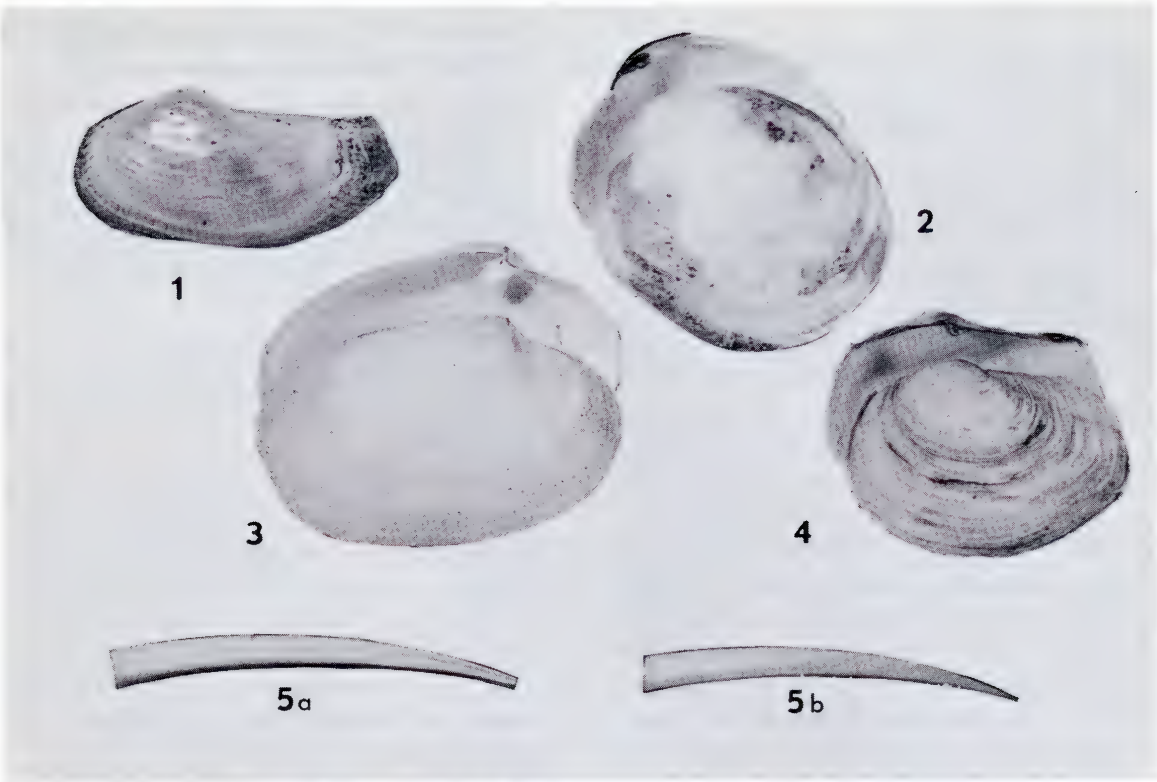

Figure 54. **1,** *Lyonsia californica*, x 2; **2,** *Mytilimeria nuttalli*, x 1.5; **3,** *Periploma planiusculum*, x 1; **4,** *Thracia curta*, x 1; **5,** *Dentalium neohexagonum*, x 2.

of ledges in the intertidal zone. Range: Southeastern Alaska to Baja California.

Family PERIPLOMATIDAE

Whitish oval shells with slightly nacreous interiors, the right valve more inflated, both valves with a spoon shaped chondrophore, buttressed internally by a posteriorly directed ridge. A triangular ossicle, a separate calcified process, reinforces the ligament between the beaks and the chondrophores. Pallial sinus shallow, siphons separate. These clams burrow in sandy bottoms offshore.

Periploma Schumacher, 1817

One species is common.

54.3 *Periploma planiusculum* Sowerby, 1834. Spoon Clam. Medium sized, the beaks near the posterior end, the chondrophore directed forward. Externally the sculpture consists of fine growth lines, internally there is a silvery luster. Length, 40-55 mm. Living outside of the surf zone along exposed beaches, frequently cast ashore after storms. Range: Point Conception, California, to northern Peru.

Family THRACIIDAE

Thin, chalky shelled, quadrate in shape, right valve the more inflated, beaks in contact, often resulting in the perforation of the beak area in the right valve. Hinge dentition absent, ligament held between poorly developed chondrophores, ligament often exposed externally as well. Pallial sinus well marked.

Thracia Sowerby, 1823

Ligament exposed externally, sculpture consisting of irregular concentric growth ridges.

54.4 *Thracia curta* Conrad, 1837. Short Thracia. Medium sized with a squared off posterior end, a ridge extending diagonally from the beaks. The concentric growth ridges are irregular and the shells may be distorted

from living in crevices in rocky rubble. The valves have a microscopically fine granular surface. Length, 20-35 mm. Range: Bering Sea, Alaska, to southern Baja California.

Class SCAPHOPODA

Scaphopods or tooth shells are curved, tubular, open at both ends. They lie partially buried on sand or mud bottoms offshore with the smaller, posterior end projecting. Water enters the mantle cavity through this end and is periodically expelled through the same opening. Through the large anterior opening project the foot, adapted for burrowing, the head, consisting of a proboscis and mouth, and numerous prehensile feeding tentacles, the captacula. Food consists primarily of microscopic organisms, such as foraminifera, captured by the captacula and drawn to the mouth.

Scaphopods are one of the smaller classes of mollusks and relatively few species are known from California. None occur primarily in the intertidal zone.

Family DENTALIIDAE

The maximum diameter of the tube is at the anterior aperture in Dentaliids and in the other recognized family, the Siphonodentaliidae, the maximum diameter of the tube is just behind the aperture.

Dentalium Linnaeus, 1758

Although several offshore species occur in southern California, only one is common in beach drift.

54.5 *Dentalium neohexagonum* Pilsbry and Sharp, 1897. SIX-SIDED TOOTH. Six longitudinal ribs give the whitish shell a flat sided surface. In large specimens the ribs are weak near the large anterior opening and finer intercalary ribs may be present. Length, 25-35 mm. Common at depths of 30-600 feet on sandy mud bottoms. Range: Monterey, California, to Baja California.

APPENDIX—SOURCES OF ILLUSTRATIONS

Illustrations presented here are original photographs that, with few exceptions have not been previously published. Thirty-eight of the gastropod photographs are of primary type specimens. Type material is cited as either a holotype or lectotype.

Localities for the specimens illustrated are given in the source list that follows. Most of the specimens are in the Los Angeles County Museum of Natural History (LACM), but some are in other museums: California Academy of Sciences, CAS; San Diego Society of Natural History, SD; Stanford University, SU; S. Stillman Berry Collection, SSB; United States National Museum, USNM. Unless otherwise stated, localities in the list are in California and the specimens are in the Los Angeles County Museum of Natural History.

SOURCE LIST

1.1 Santa Barbara Is.
1.2 Palos Verdes Peninsula
2.1 Santa Cruz Is.
2.2 Santa Cruz Is.
2.3 San Nicholas Is.
3.1 Carmel
3.2 Santo Tomas, Baja California
3.3 LACM 1143, holotype, Carmel
3.4 SU, San Pedro
3.5 USNM 59273, lectotype, Monterey
3.6 Anaheim Bay
3.7 Carmel
4.1 Carmel
4.2 Carmel
4.3 Coronado Ids., Baja California
4.4 San Pedro
4.5 Palos Verdes Peninsula
5.1 San Pedro
5.2 Santa Monica
5.3 Laguna Beach
5.4 Monterey
5.5 Santa Monica
5.6 Palos Verdes Peninsula
6.1 Palos Verdes Peninsula
6.2 Palos Verdes Peninsula
6.3 Fort Ross, Sonoma County
6.4 Mission Bay
6.5 Carmel
7.1 Carmel
7.2 SU, Long Beach
7.3 SU, San Diego
7.4 USNM 206134, holotype, Monterey
7.5 SU, San Pedro
7.6 SU, San Diego
8.1 USNM 16280, lectotype, Catalina Is.
8.2 Coronado Ids., Baja California
8.3 Palos Verdes Peninsula
8.4 SD, Mission Bay
8.5 Palos Verdes Peninsula
9.1 SU, Palos Verdes Peninsula
9.2 USNM, Mission Bay
9.3 SU, Ensenada, Baja California
9.4 SU, San Benito Ids., Baja California
9.5 USNM 125314, holotype, Guadalupe Is., Baja California
9.6 Coronado Ids., Baja California
9.7 La Jolla
9.8 San Clemente Is.
10.1 Palos Verdes Peninsula
10.2 Palos Verdes Peninsula
10.3 Santa Cruz Is.
10.4 USNM, Coronado Ids.
10.5 San Clemente Is.
10.6 SSB, Farnsworth Bank, Catalina Is.
11.1 Alamitos Bay
11.2 Carmel
11.3 CAS 2741, holotype, Pt. Loma, San Diego County
11.4 Todos Santos Id., Baja California
11.5 Punta Banda, Baja California
11.6 San Pedro
11.7 Long Beach
12.1 USNM 219564, lectotype, San Diego
12.2 USNM 213698, holotype, San Pedro
12.3 USNM 213699, lectotype, San Pedro
12.4 USNM 4338, lectotype, Puget Sound, Washington
12.5 Monterey
12.6 USNM 15573, lectotype, San Diego
12.7 USNM 213541, lectotype, La Jolla
12.8 Palos Verdes Peninsula
12.9 Coronado Ids., Baja California
12.10 USNM 1558, holotype, "Lower California"
12.11 USNM 15570, holotype, San Diego
12.12 Santa Cruz Is.
13.1 Carmel
13.2 USNM 107281, lectotype, San Pedro
13.3 Newport Bay
13.4 USNM 158777, holotype, Point Loma, San Diego County
13.5a&b La Jolla
13.6 USNM 105488, lectotype, San Diego
13.7a&b Palos Verdes Peninsula
14.1 USNM 15719, lectotype, San Diego
14.2 USNM 340724, holotype, San Diego
14.3 USNM 14930, lectotype, San Diego
14.4 USNM 60927, lectotype, San Diego
14.5 USNM, San Pedro
15.1 SU, San Pedro
15.2 San Pedro
15.3 Mission Bay
15.4 San Clemente Is.
15.5 USNM 334650, lectotype, Monterey
16.1 Playa del Rey
16.2 USNM, San Pedro
16.3 Santa Cruz Is.
16.4 Carmel
16.5 San Ignacio Lagoon, Baja California
16.6 USNM 195196, lectotype, San Pedro
16.7 USNM 109510, lectotype, San Pedro
16.8 USNM, San Diego
16.9 Ensenada, Baja California
16.10 USNM 152206, lectotype, San Pedro

17.1 SU, San Pedro
17.2 SU, San Pedro
17.3 San Pedro
17.4 USNM, Santa Barbara
17.5 SU, San Diego
17.6 Laguna Beach
17.7 Laguna Beach
18.1 Punta Banda, Baja California
18.2 San Pedro
18.3 SU 9721, holotype, Seal Beach
18.4 Pt. Conception
18.5 SU, San Pedro
18.6 Palos Verdes Peninsula
18.7 Monterey
18.8 SU, San Pedro
19.1 San Pedro
19.2 USNM 172859, holotype, Monterey
19.3 Mission Bay
19.4 Anaheim Bay
19.5 SU, San Pedro
19.6 USNM 111368, lectotype, San Diego
19.7 LACM 1059, holotype, Anaheim Bay
20.1 SU, Monterey
20.2 Laguna Beach
20.3 Carmel
20.4 Laguna Beach
20.5 San Pedro
20.6 Palos Verdes Peninsula
20.7a Farnsworth Bank, Catalina Is.
20.7b SU, Farnsworth Bank
21.1 SU, San Diego
21.2a USNM, San Diego
21.2b USNM, San Pedro
21.3 Mission Bay
21.4 USNM, Santa Rosa Is.
21.5 San Diego
21.6 SU, San Pedro
22.1 Laguna Beach
22.2 SD, Catalina Is.
22.3a SU, Palos Verdes Peninsula
22.3b San Miguel Is.
22.4 USNM 46994, lectotype, Monterey
22.5a&b San Miguel Is.
22.6 USNM, Laguna Beach
22.7 USNM, Monterey
22.8 USNM 56912, lectotype, Catalina Is.
22.9 SU, San Pedro
23.1 SU, San Onofre
23.2 San Clemente Is.
23.3 SU, San Diego
23.4 SU 6455, holotype, Catalina Is.
24.1 Mission Bay
24.2 Shell Beach, San Luis Obispo County
24.3 USNM 60006, lectotype, Coronado Ids., Baja California
24.4 Playa del Rey
24.5 Corona del Mar
24.6 Doheny Beach, Orange County
25.1 USNM 14953, lectotype, San Diego
25.2 USNM, San Diego
25.3 Palos Verdes Peninsula
25.4 Catalina Is.
25.5 USNM, San Clemente Is.
25.6 Palos Verdes Peninsula
25.7 Carmel
26.1 Tijuana River, Baja California
26.2 Catalina Is.
26.3 San Pedro
26.4 USNM, San Pedro
26.5 USNM, Catalina Is.
26.6 Palos Verdes Peninsula
26.7 Pt. Conception
27.1 La Jolla
27.2 Pacific Grove
27.3 USNM 23240, holotype, Catalina Is.
27.4 Catalina Is.
27.5 Carmel
27.6 SU, San Diego
27.7 SU, Palos Verdes Peninsula
28.1 USNM, Santa Barbara
28.2 Mission Bay
28.3 SU 8655, holotype, San Pedro
28.4 Hermosa Beach
29.1 USNM, San Pedro
29.2 SSB, Monterey
29.3 USNM, Santa Barbara
29.4 USNM 203670, holotype, San Diego
29.5 Farallon Ids.
29.6 San Pedro
29.7 Santo Tomas, Baja California
30.1 Redondo Beach
30.2 Anaheim Bay
30.3 USNM, Palos Verdes Peninsula
30.4 USNM, Monterey
30.5 San Pedro
30.6 Dana Pt., Orange County
30.7 Punta Banda, Baja California
31.1 Laguna Beach
31.2 Mission Bay
31.3 SD, San Diego
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31.7 USNM 56179, lectotype, Monterey
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32.2 San Clemente Is.
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32.9 Coronado Ids., Baja California
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